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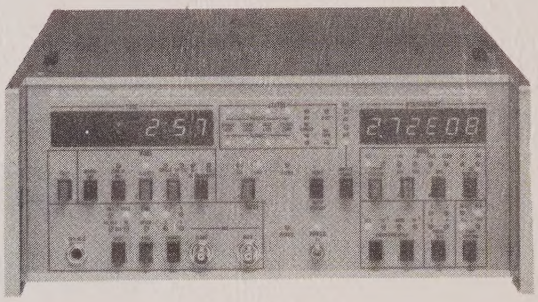
OPERATOR'S MANUAL

Model 4654A
Error Rate Analyzer



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Model 4654A
Error Rate Analyzer

Operator's Manual

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INSTRUMENTATION

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CHAPTER 1
GENERAL INFORMATION

1.1 GENERAL

This instruction manual contains information for installing and operating the Scientific-Atlanta Model 4654A Error Rate Analyzer. The theory of operation, maintenance, parts listing, and applicable drawings are contained in a separate instruction manual identified - MAINTENANCE.

We recommend before operating this unit, or attempting a repair adjustment, reading the appropriate sections in these manuals carefully. Factory or customer specified modifications, when applicable, and/or general instruction manual updating will be described in an Update Sheet inserted in the rear cover envelope of the appropriate Instruction Manual.

1.2 PURPOSE OF EQUIPMENT

The complete Model 4654A Error Rate Analyzer Set consists of two units: (1) the Model 4653A Transmitter, and (2) the Model 4654A Analyzer. These units are designed to aid in testing digital-to-digital measurements on digital transmission equipment such as DS1, DS1C, or DS2 digital data links. The Model 4653A Transmitter generates test signals and the Model 4654A Analyzer performs a variety of error measurements on the received data. Normally, the Model 4653A Transmitter is connected to a DS1/1C/2 transmitter which sends digital data over various media (microwave, optical, cable) while the DS1/1C/2 receiver output is fed into the Model 4654A Analyzer for error measurements. The Model 4654A can also monitor two external dc voltages and two switch closures with the External Event Monitor. This could be used to monitor AGC voltage on digital radios to correlate changes in AGC and alarms with bit error rate.

Alternately, the Model 4654A Analyzer can be operated remotely with either IEEE-488 bus or RS-232C data links. The Model 4654A Analyzer can also drive the optional Model 4650 Printer from its power supply to provide permanent records of local data logging. The printed display is that of a 21-column alphanumeric format.

The Model 4653A/4654A Transmitter-Analyzer configuration provides total measurement capability for field use, commissioning, or laboratory tests.

1.3 GENERAL DESCRIPTION

Normally the Model 4654A Analyzer recovers the clock signal from the incoming data stream and synchronizes to it. After synchronization, the analyzer circuits perform bit-by-bit measurements for bit errors and bipolar violations. A real-time clock (with month, day, hours, minutes, and seconds capability) provides timing for error logging. The clock feature can also be operated in an ELAPSED (or count up) mode or preset for a TIMED (or count down) test. While operating in the time modes, error-seconds, total errors, and average bit error rates are measured for both error types. Untimed or instantaneous error rates for bit and bipolar violations can be measured every 0.25 or 2 seconds in the fast and slow error rate modes, respectively.

Input signals to the Model 4654A Analyzer can be either DS1/1C/2 bipolar or NRZ unipolar format. The analyzer can also drive an optional local printer (Model 4650) for data logging. For remote operation applications, the unit can be operated from either an IEEE-488 bus (Part No. 304208) or through an RS-232C interface (Part No. 304209).

1.4 TECHNICAL CHARACTERISTICS

A summary of technical characteristics for the Model 4654A is provided in the following specifications.

DATA INPUT	
Rates	Accepts standard DS1/1C/2 rates
Impedance	Balanced, 110Ω
Input Connector	Accepts a WE 310 plug
Return Loss	Greater than 30 dB for a 20 ns rise time pulse for signal voltage between ±0.2 and ±3.0 volts
Sensitivity	AGC operates over full range of transmitter outputs. LO/DSX and HI selectable for DS2 inputs
NRZ INPUTS	
Clock	75Ω, dc coupled, TTL level
Data	75Ω, dc coupled, TTL level
DATA FORMATS	Switch selectable for PRBS or non-PRBS data inputs. Recognizes all transmitter data formats including programmed sequence to perform bit error measurements.
CHANNEL SELECT	Selects any or all DS1 channels from DS1C or DS2 data stream for error measurement.
SYNCHRONIZATION[1]	
Mode:	PRBS automatic at error rates up to 10^{-2} in less than two hundred clock cycles
Frame In-Sync	F-Frame: 8 successive F bits match M-Frame: 3 M bits match in an M-Frame
Frame Out-of-Sync	3 F-bit errors between M4 bits 3 successive M-Frames have M-bit errors
DS1 Framing	Synchronizes in less than 5 ms.
CLOCK EXTRACTION:	PLL with an equivalent Q of 110 ± 20
MEASUREMENT MODES[2]	
ERROR-SECONDS	Counts and displays number of seconds when BER exceeds selected threshold during a TIMED or ELAPSED time test. Error-seconds can also be indicated as a percent (%) of total seconds. Internal jumper selects synchronous or asynchronous measurement technique.
TOTAL ERRORS	Count and display total number of errors since beginning of TIMED or ELAPSED test for errored seconds above selected threshold.

AVERAGE (AVG) BER	Calculates and displays error rate based on total number of errors (in error-seconds above selected threshold) divided by the total number of bits since beginning of the TIMED or ELAPSED time test.
BER	Count and display error rate averaged over short or long interval (fast or slow update)
BURST ERRORS	Consecutive errored milliseconds for selected error type (Bit or BPV)
DC Monitor	Two DC VOLTAGE inputs and two DRY CONTACT inputs can be monitored. The first display position in the MEASUREMENT DISPLAY contains the status of the selected DRY CONTACT input (blank = Inactive, A = Active, and H = has been active during the timed test). The remainder of the display shows DC Voltage for the selected input.
STATUS INDICATORS	
GATING	ON, indicates a measurement in process. Blinks when display updates.
POWER LOSS	Flashes after power failure. On continuously after manually RESET.
ALL ONES	ON, indicates all ones data in selected DS1 Channel.
X-BIT	OFF, indicates X-bit is a 1 ON, indicates X-bit is a 0
The following four conditions have two indicators each to show the previous status (to indicate the condition has existed since the last manual RESET) and current operating status. Minimum ON time for present indicators is 100 milliseconds.	
(1) Signal Loss	ON, indicates signal loss or signal below operating level.
(2) Frame Loss	ON, indicates a frame loss (see synchronization).
(3) Data Loss	ON, indicates a loss of synchronization of internally generated data pattern which is determined by 16 or more errors in 128 clock cycles.
(4) Excess Zero	ON, indicates an excess string of zeros, 16 or more for DS1, 34 or more for DS1C, and six or more for DS2.

IN 1 and IN 2 DC Threshold	On when DC VOLTAGE for respective input exceeds programmed upper threshold or is less than programmed lower threshold. LED flashes at the end of a test if that input went out of threshold during the test.
REAL-TIME CLOCK and TIMER Time Display	Seven-digit numeric display shows time of day, month/day, elapsed time, time remaining in test, or DC voltage thresholds as indicated by the associated mode indicators. Timekeeping is accomplished by means of a real-time clock circuit backed up by a Ni-Cad battery to permit timekeeping in the absence of external power, and recovery upon re-application of power. With DC MONITOR Option installed, voltage thresholds from -40.00 to 40.00 may be entered in the TIME display.
Clock Power	NI-CAD rechargeable battery. Recharged when analyzer power on; three months operation without recharging.
Untimed Mode	Count and display error rate with FAST or SLOW update.
Timed Modes	Timer can be set to count down from a preset time, TIMED mode; or set to ELAPSED to count up. While timer is running, all error types are counted simultaneously for ERROR-SECONDS (TOTAL and %), TOTAL ERRORS and AVG. BER. BURST errors (TOTAL or LENGTH of last burst) are counted for selected error type.
MEASUREMENT DISPLAY	Select error type or dc voltage to be displayed. All error types are simultaneously counted and switches select type to be displayed.
Bit Errors	Bit errors are detected by comparing an internal data bit sequence or pattern with a similar received sequence. Bit errors can be measured on PRBS and non-PRBS patterns.
Bipolar Violations	DS1/1C, violation of alternate mark inversion coding. DS2, violation of B6ZS coding.

DC Monitor	Leftmost display position is status of selected DRY CONTACT input (blank = Inactive, A = Active, H = has been active during the test). The rest of the display is DC voltage from -40.00 to 40.00. Input 1 data is displayed only if DC MONITOR IN 1 is selected and input 2 data is displayed only if DC MONITOR IN 2 is selected.
Error Threshold	Switch selectable thresholds between 10^{-6}, PROG, 10^{-3} or all errors during one-second interval.
MEASUREMENT RANGE	
Error Rates	1.00 x 10^{-2} to 1.0 x 10^{-50}
Counts (error-seconds and total errors)	0 to 999,999 in decimal notation then 1.00 x 10^{6} to 9.99 x 10^{50} in scientific notation.
DC Voltage	-40.00V to 40.00V (± 0.40V)
SYNC OUTPUTS[3]	Rear panel BNC's for CLOCK, FRAME, PRBS-SYNC, ERROR, and DATA.[3]
REMOTE CONTROL	Unit can operate via IEEE-488 bus or RS-232C
GENERAL	
Power Supply	110/220V ac, 50-60 Hz -22V to -60V dc, positive ground 60 watts
Non-Volatile RAM and Real-Time Clock	Non-volatile RAM for operating mode and measurement storage, Real-Time clock using internal NI-CAD battery.
Temperature	Operating: 0° to 50°C Storage: -20° to 50°C
Dimensions	13"W x 15"D x 5.25"H
Weight	25 lbs

NOTE: 1 The T-1 Serial Receiver IC indicates loss of carrier if it receives 31 consecutive zeros. Frame sync search begins on the next 1. Therefore, the analyzer will not operate with "all zeros" data when DS1 is framed.

2 If XMTR sends DS1C/DS2 unframed, the analyzer will synchronize on bit pattern and measure bit errors.

3 FRAME output produces a pulse at every framing bit location in DS1. In DS1C or DS2, it produces a pulse at the M1 bit in each M-Frame.

MODEL 4650 PRINTER (OPTIONAL)

Interface Format	Parallel input, eight-bit-parallel/character serial, standard ASCII format, 21 characters/line.
Modes	ALL or Partial printout modes selectable on the 4654A (displays Error Burst Data in ALL mode). Conditions which trigger printout selectable on the 4654A front panel. Printout may be triggered by (a) Bit Error Rate greater than selected threshold, (b) a DC Voltage input going out of threshold, or (c) either of these conditions. Logs on Error-Second until 40 continuous Error-Seconds are encountered. (This log mode is suppressed for Single or Repeat Timed tests of less than 1 hour duration.) Logs on PRINT command from front panel of the 4654A. Logs at end of test.
Power	Derived from the 4654A through interface cable.
Printer Format	Several typical printouts follow: (See Figure 1.1)

```
0707 14:22:55F
POWER DOWN
0707 14:22:58F
POWER UP
```

MOMENTARY POWER FAILURE

```
0707 14:23:30          0
START ELAPSED TEST
DS2 HI PRBS    CH 1
PROG THRES 2.24000E-5
B=BIT V=BPV
DC THRESHOLDS, HI/LO
  IN 1 +25.50/-40.00
  IN 2 +14.92/-19.83
FRAMED DATA
ALARM 1 OFF
ALARM 2 OFF
```

START OF SAMPLE ELAPSED TEST. HEADER SHOWS DATE, TIME, TEST TYPE, INPUT AND DATA TYPE, CHANNEL PROG THRES VALUE, DC THRES VALUES, SIGNAL AND ALARM MONITOR STATUS.

```
0707 14:23:46         16
SIGNAL LOSS
```

SIGNAL LOSS INDICATION

```
0707 14:23:46         16
T=0 ES  TOTERR AVGBER
B      1 1.64+6       1
V      1 1.47+6       1
DCV HI    LO    OUTSEC
1+24.07 +24.06       0
2+11.95 +11.95       0
```

PRINTOUT TRIGGERED BY ERRORS

```
0707 14:23:53         23
GOOD DATA
X-BIT OFF
```

SIGNAL, FRAME, AND DATA SYNC REGAINED

```
0707 14:25:41       131
T-6 ES  TOTERR AVGBER
V     21 2.12+7 5.01-5
DCV HI    LO    OUTSEC
1+27.08 +24.06      12
2+13.39 +11.95       0
```

PARTIAL PRINTOUT FOR SELECTED THRESHOLD (10^{-6}) ONLY. FORMAT CONTROLLED BY DCV/BER AND ALL/PART PRINT BUTTONS

```
0707 14:27:05F      182
          ALL    BER>E-6
ERR B 2.13+7   2.13+7
    V 2.12+7   2.12+7
ES  B      37       36
    V      35       32
%ES B 20.330   19.780
    V 19.231   17.582
%EF B 79.670   80.220
    V 80.769   82.418
BER B 7.14-2   7.14-2
    V 1.84-2   1.84-2
      >2.24-5 BER>E-3
ERR B 2.13+7   2.13+7
    V 2.12+7   2.12+7
ES  B      31       11
    V      31        8
%ES B 17.033    6.044
    V 17.033    4.396
%EF B 82.967   93.956
    V 82.967   95.604
BER B 7.14-2   7.14-2
    V 1.84-2   1.84-2
DCV HI    LO    OUTSEC
1+30.58 +22.22      41
2+15.18 +11.03      20
 ERRORS: 1OUT   2OUT
  BIT    9057   8554
  BPV    4954   1729
ERROR BURSTS, MSEC
   1-10   11-99  100+
B  2057      0      3
```

FINAL PRINTOUT AT END OF A TEST, MAXIMUM LENGTH. PRINTS DATA FOR ALL ERROR TYPES IN ALL THRESHOLDS, DCV MAX AND MIN VALUES, SECONDS OUT OF THRESHOLD, NUMBER OF ERRORS WHILE DC OUT OF THRESHOLD, AND BURST DATA.

```
0707 14:27:30F      182
T=0 ES  TOTERR AVGBER
B     37 2.13+7 7.14-2
V     35 2.12+7 1.84-2
DCV HI    LO    OUTSEC
1+30.58 +22.22      41
2+15.18 +11.03      20
```

FINAL PRINTOUT (PARTIAL)

Figure 1.1. Local Data Logging Sample Printout from a Model 4650 Optional Printer

CHAPTER 2
INSTALLATION

2.1 GENERAL

Initial preparation of the analyzer for operation along with various set-up configurations are described below. Operating instructions are provided in Chapter 3 - OPERATION.

2.2 UNPACKING AND INSPECTION

Carefully unpack the shipping cartons observing all printed instructions. Separate the packing material from the main unit and any packages of loose items (hardware, cables, connectors, etc.). Temporarily set the shipping cartons and packing material aside in a safe place and inspect the unit and associated items (if any) for shipping damage. If damage is evident, contact both the carrier and the nearest Scientific-Atlanta sales representative immediately. Save the packing materials and shipping papers for inspection by the carrier's representative. Do not return a unit to Scientific-Atlanta without receiving specific return shipment instructions.

Save the shipping cartons and packing material even after satisfactory operation of the Model 4654A Analyzer is determined. They may be useful for storage, or for protection during future transport of the equipment.

An inventory checklist is provided in Section 2.3 for accessories supplied with these units. Should an item be missing or damaged from the accessory kit, contact your nearest Scientific-Atlanta representative for assistance.

2.3 ACCESSORIES SUPPLIED

The Model 4654A Analyzer comes complete with the following Accessory Kit (Part No. 304138).

___ Operator's Manual (Part No. 256027)
___ Power Cord (Part No. 89672)
___ Fuses:
  ___ .5 Amp Slo Blo (Part No. 71217)
  ___ 1.5 Amp Slo Blo (Part No. 71222)
  ___ 2 Amp Slo Blo (Part No. 71223)
  ___ 4 Amp Slo Blo (Part No. 71229)
  ___ 5 Amp Slo Blo (Part No. 71232)
  ___ 10 Amp Slo Blo (Part No. 71236)
___ Connector, Rect. Plug Housing (Part No. 89689)
___ Connector, Contact Pin (Part No. 87460)

In addition, a Model 4654A Service Accessory Kit (Part No. 304139) is available. The kit contains the following items:

1. Maintenance Manual (Part No. 256028)
2. Printed Circuit Board Extender (Part No. 221035)
3. Card Puller (Part No. 254439)

For further information on obtaining a Service Accessory Kit, contact your local Scientific-Atlanta representative, or write/call: Scientific-Atlanta, Instrumentation Factory Service Department, 4388 Shackleford Road, ATL 28-B, Norcross, Georgia 30093, Phone (404)-925-5277.

2.4 INSTALLATION

A. POWER SOURCE

The Model 4654A Analyzer is available with ac only or ac/dc power supplies. The ac only type operates from 115V/220V 50-60 Hz. The ac/dc operates from 115V/220V 50-60 Hz or from a positive ground battery source providing from -22V to -60V dc.

CAUTION

BE SURE THE FRONT PANEL POWER SWITCH IS IN THE OFF (DOWN) POSITION BEFORE CONNECTING BATTERY SOURCE VOLTAGE. ALTHOUGH THE CIRCUITS ARE VOLTAGE PROTECTED, IT IS POSSIBLE TO BLOW A PROTECTING FUSE WHICH IS MOUNTED INTERNALLY AND REQUIRES PARTIAL DISASSEMBLY TO PERMIT REPLACEMENT.

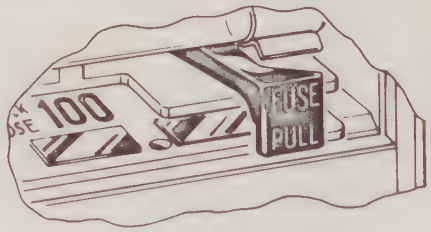
If there is any question, check the source with a meter to verify that the voltage is within operating range required by the equipment. Connecting the equipment to both ac and dc power sources simultaneously is permissible. The power supply circuit rectifies and filters the stepped down ac voltage which is directed through a diode OR circuit with the applied dc source voltage. The greater voltage will act as the power source for the equipment.

The rectified ac source potential is approximately 55V dc. If the dc source potential is less than 55V dc, the ac source will power the equipment. Likewise, if the dc potential is greater than 55V dc, the dc source will power the equipment. This arrangement permits highly reliable uninterrupted service modes. The equipment will operate from the higher source potential only and presents minimum drain on the unused source.

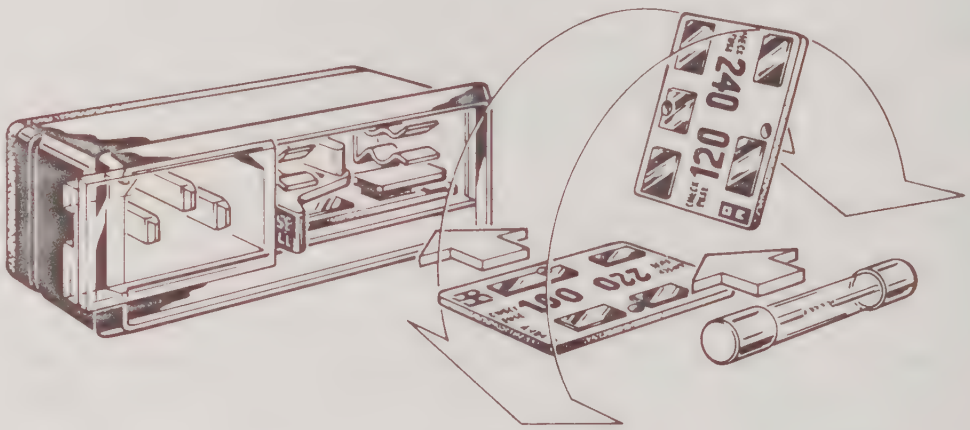
Occasionally, a fuse fails and requires replacement. For ac fuse replacement, refer to Figure 2.1. Use only the proper fuse size and rating labeled on the rear panel. DC voltage input fuses are located on a printed circuit board mounted to the inside of the rear panel. Access to these fuses is possible after removing the equipment's top and bottom covers. On the ac only models, the dc voltage fuses are on the power supply board which can be accessed by removing the top cover only.

B. TYPICAL TEST CONFIGURATIONS

The complete Model 4653A/4654A Error Rate Analyzer Set is intended to make digital-to-digital measurements on DS1, DS1C, and DS2 digital transmission equipment. Applications can be extended into the DS3 domain with the addition of the Model 4656 DS3 to DS2 Demultiplexer. In general, perform mea-



Operating voltage is shown through the sliding plastic window.



HOW TO SELECT OPERATING VOLTAGE

1. Remove the ac power cord connector.
2. Slide the plastic window to the left.
3. Carefully operate FUSE PULL tab to the left.
4. Carefully remove both the fuse and printed circuit board. A small hole is provided to accommodate a wire pull if necessary.
5. Correctly orient the printed circuit board so the desired voltage is located on the top left side.
6. Carefully return the printed circuit board to the original location. Be sure it is securely seated.
7. Return FUSE PULL tab to the normal position.
8. Replace the original fuse with one selected for correct fuse value.

Illustrations courtesy of Corcom Corp., Chicago, Ill.

Figure 2.1. Selecting the Proper Operating Voltage

surements in either a loop-back or end-to-end configuration. A single set (4653A/4654A) is used for loop-back testing, while two sets are required to perform the end-to-end tests in both directions. Live traffic bipolar violation errors are monitored with a single Model 4654A Analyzer. Bit errors or bipolar violations are inserted into live traffic by feeding the live traffic bipolar signal into a Model 4654A Analyzer. The CLOCK and DATA outputs from the rear panel of the receiver are connected to the CLOCK and DATA inputs on the front panel of a Model 4653A Transmitter. The transmitter then regenerates a bipolar signal. Errors can be inserted using the AUTO or SINGLE error insert switches. The AGC Voltage of Digital Radios is measured and correlated with Bit Error. Alarms are monitored by the two dry contact monitors with the optional External Event Monitor. A permanent copy of test results is provided by using the optional Model 4650 Printer.

1. End-to-End Test

Two Model 4653A/4654A sets are required to perform simultaneous End-to-End Tests in both directions. A typical setup is illustrated by the block diagram in Figure 2.2. Patching the respective Model 4653A Transmitter and Model 4654A Analyzer into system signal paths, each Model 4654A Analyzer will test evaluate the transmission of the opposite end Model 4653A Transmitter. Common tests include bit and bipolar violation error rates, total errors, error-seconds, etc. The results are retained on permanent copy when the Model 4650 Printer Option is used.

2. Loop-Back Test

Both the Transmitter and Analyzer of a Model 4653A/4654A arrangement are required to perform Loop-Back Tests on cable, digital radio, and fiber optics systems, or on digital modems. The "channel-under-test" transmitter output is connected to the system receiver. The output signal from a Model 4653A Transmitter connects to the system transmitter and a Model 4654A Analyzer connects to the system receiver output. This setup is illustrated in Figure 2.3.

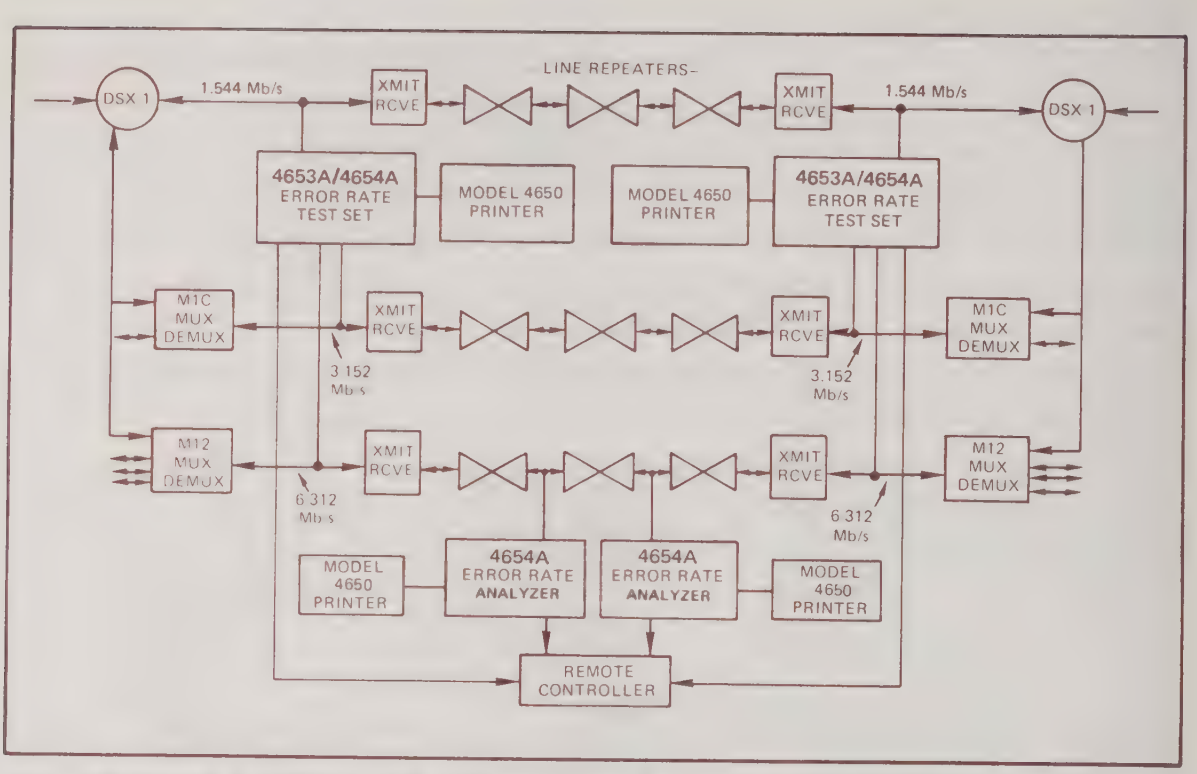


Figure 2.2. Typical Configurations for Testing Digital Networks with the Model 4653A/4654A Error Rate Analyzer Set

3. Digital Modem Testing

The Model 4653A/4654A equipment can be used for either production or field testing on digital subsystems which include the modulator/encoder/scrambler. A typical connection arrangement is shown by the block diagram in Figure 2.4.

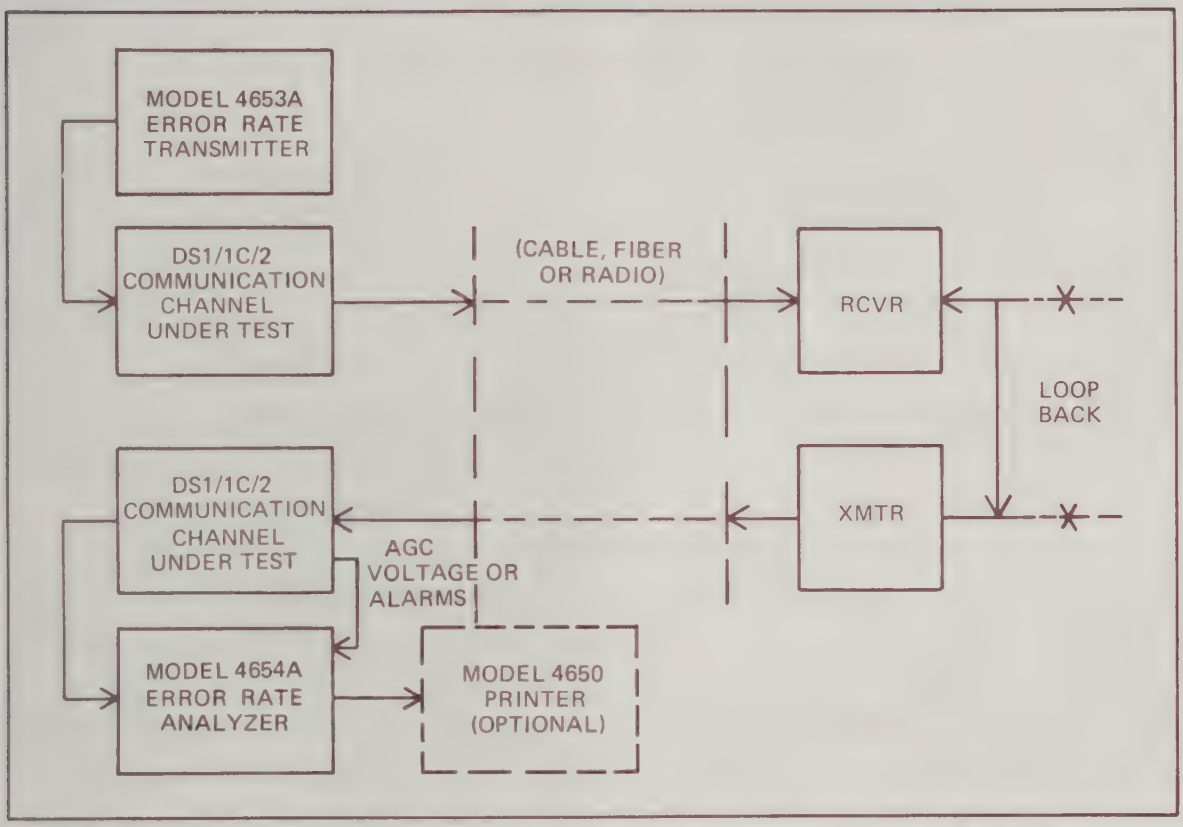


Figure 2.3. System Loop-Back Test Using Model 4653A/4654A Equipment, Block Diagram

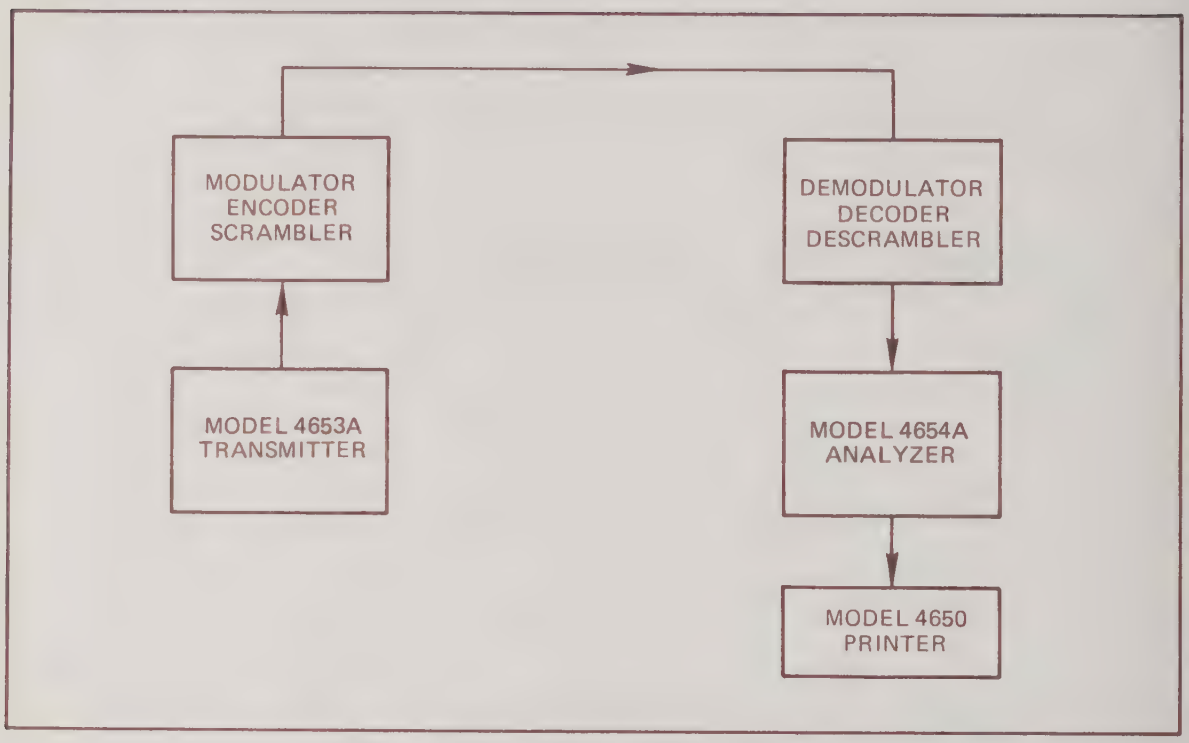


Figure 2.4. Digital Modem Test

CHAPTER 3
OPERATION

3.1 GENERAL

Read this chapter thoroughly before actually using the Model 4654A Analyzer. While the equipment cannot be damaged by front panel control settings, an understanding of the control functions reduces the time required to obtain valid measurements. Instructions for initial start-up and general operation are discussed in detail.

The Model 4654A Analyzer provides the circuitry required to: (1) recover the data clock, (2) synchronize on the framing bits, (3) synchronize to the transmitted data patterns, (4) make bit-by-bit error measurements, (5) select the input signal level, (6) select the error type to be displayed, and (7) provide a real-time clock also used to make timed measurements in three different modes. The Model 4654A Analyzer drives an optional Printer (Model 4650) to make a permanent log of measurements. Operation of either the Analyzer or Analyzer/Printer combination is remotely controlled through optional interface provisions adapted to IEEE-488 (Option 304208) or to RS-232C (Option 304209).

3.2 FRONT PANEL CONTROLS AND INDICATORS

The front panel control switches and indicators of the Model 4654A Analyzer are numerically identified in Figure 3.1. Understanding these control switches and indicators before initiating a test, provides results containing the information desired. Functions of the switches and indicators are listed in Table 3.1.

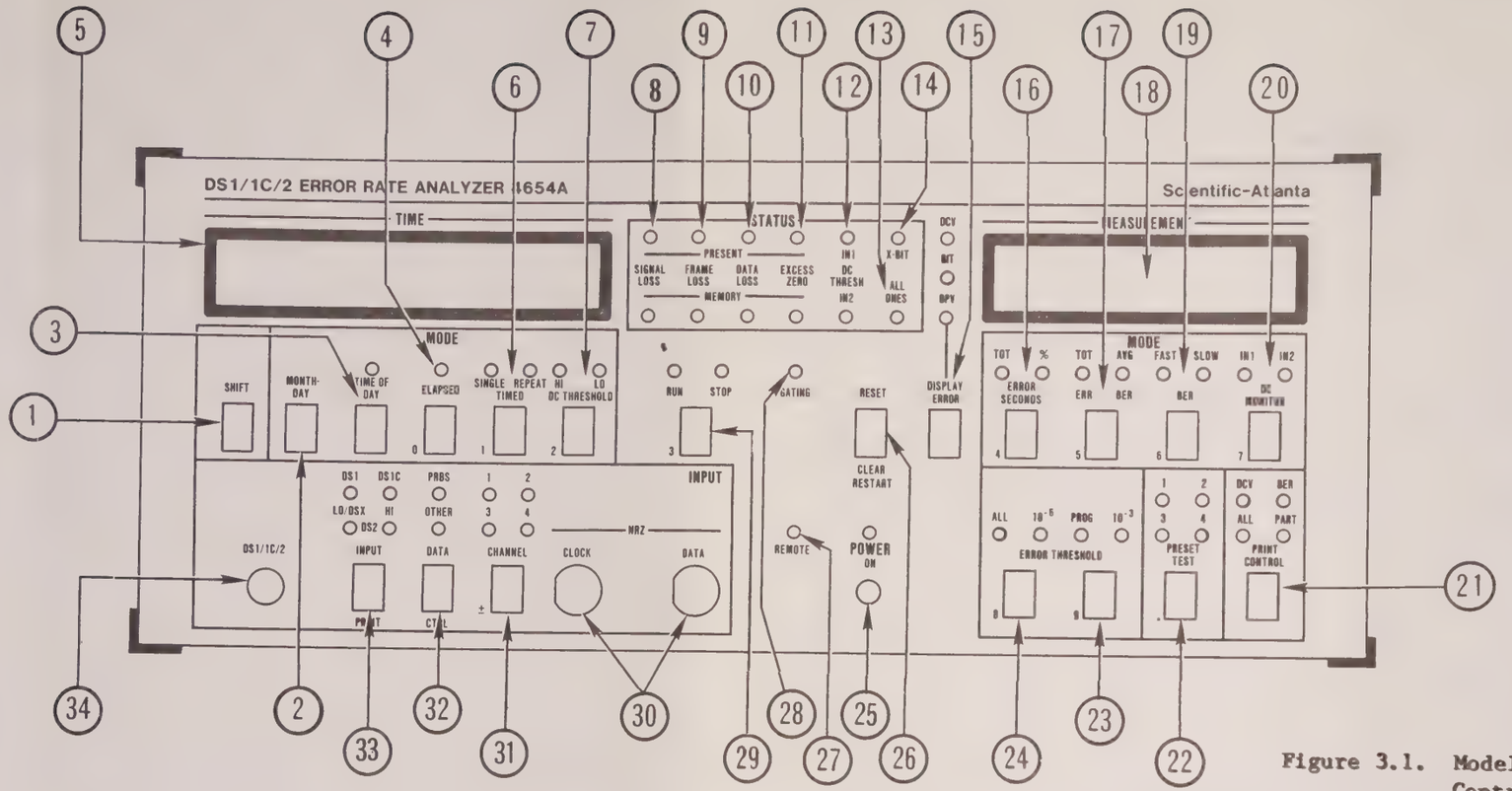


Figure 3.1. Model 4654A, Front Panel Controls and Indicators

Table 3.1
Identification of Controls and Indicators

Reference Symbol	Panel Decal	Functional Description
1	SHIFT Switch	This switch operates as a dual function key analogous to a typewriter "shift key". In the normal (out) position, front panel switches operate as labeled. When the SHIFT (1) switch is depressed, front panel switches with red decals below them are operated into a secondary function. This allows for front panel switches to be used to enter new values into the TIME (5) display as desired.
2	MONTH-DAY Switch	Pressing this switch causes the month and day numbers to temporarily appear in the TIME (5) display. If the SHIFT (1) switch is held depressed, a new value of month and day can be entered. Final loading of the new value is entered by pressing the MONTH-DAY switch before releasing the SHIFT (1) switch.
3	(MODE) TIME OF DAY Switch and Indicator	Pressing this switch causes the TIME (5) display to continuously present the time of day in 24 hour format from the internal real-time clock. If the SHIFT (1) switch is held depressed, a new value of hours, minutes, and seconds can be entered. Final loading and synchronizing of the new value is entered by pressing the (MODE) TIME OF DAY switch before releasing the SHIFT (1) switch. The indicator above the switch illuminates to identify the function as being presented in the TIME (5) display.

Table 3.1 - continued

Reference Symbol	Panel Decal	Functional Description
4	(MODE) ELAPSED Switch and Indicator	This switch provides for selection of the ELAPSED Mode of timer operation in which the TIME (5) display counts up from an entered value in the TIME (5) display while the RUN (29) indicator is illuminated. The ELAPSED Mode is used to totalize error-seconds, errors, and average BER. The indicator above the switch illuminates to identify this function as being presented in the TIME (5) display. This switch is also used to enter the number "0" into the TIME (5) display.
5	TIME Display	These seven characters provide indication of MONTH-DAY, TIME OF DAY, the length of an ELAPSED time test, or the time remaining for a TIMED test.
6	(MODE) TIMED SINGLE-REPEAT Switch and Indicator	This switch provides for selection of the Timed Countdown Mode of timer operation in which TIME (5) display counts down. In Single, the time display counts down from an entered value and stops when the TIME (5) display reaches zero. This mode is used to totalize errors for a preset interval. In Repeat, the time display timer counts down from an entered value and repeats the countdown operation until the STOP (29) function is selected. This mode is used to totalize errors and dump the measurement to an external device on a periodic basis. The indicator above the switch illuminates to identify this function as being presented in the TIME (5) display. This switch is also used to enter a "1" into the TIME (5) display.
7	HI-LO DC THRESHOLD Switch	This switch provides selection of HI or LO DC THRESHOLD to be displayed in the TIME DISPLAY (7). This switch may be used in conjunction with the DC MONITOR

Table 3.1 - continued

Reference Symbol	Panel Decal	Functional Description
7	HI-LO DC THRESHOLD Switch (continued)	switch (22) to display the high and low thresholds for Input 1 or Input 2.* The HI or LOW indicators illuminate to identify the threshold being presented in the TIME display. They flash to indicate the setting of a threshold. Pressing the DC THRESHOLD switch while holding in the SHIFT (1) switch causes a ONE to be entered in the TIME display. * Note: Pressing the DC THRESHOLD switch forces the DC MONITOR MEASUREMENT MODE, but pressing the DC MONITOR switch does not force the DC THRESHOLD MODE.
8	(STATUS) SIGNAL LOSS Present and Memory	The Present (Red) indicator illuminates as an alarm when there is no analyzer input signal or the input signal is of insufficient amplitude. The Memory (Yellow) indicator illuminates if this condition has occurred since the last RESET.
9	(STATUS) FRAME LOSS Present and Memory	The Present (Red) indicator illuminates as an alarm when the analyzer cannot find the framing pattern in the received input signal. The Memory (Yellow) indicator illuminates if this condition has occurred since the last RESET. (See Synchronization Specifications.)
10	(STATUS) DATA LOSS Present and Memory	The Present (Red) indicator illuminates as an alarm when the analyzer has not synchronized its internal Data Generator to the received data pattern. The Memory (Yellow) indicator illuminates if this condition has occurred since the last RESET. (See Data Loss Specifications.)

Table 3.1 - continued

Reference Symbol	Panel Decal	Functional Description
11	(STATUS) EXCESS ZERO Present and Memory	The Present (Red) indicator illuminates as an alarm when the analyzer has received too many consecutive zeros. The Memory (Yellow) indicator illuminates if this condition has occurred since the last RESET. (See Excess Zero Specifications.)
12	IN 1 - IN 2 DC THRESHOLD (STATUS)	These indicators illuminate when their respective DC Input voltages become greater than the high threshold or less than the low threshold. They flash at the end of a timed test to indicate an out-of-threshold condition occurred at some time during the test.
13	(STATUS) ALL ONES	This indicator illuminates to indicate the data signal being received in the selected channel (31) is composed of only ones.
14	(STATUS) X-BIT	Indicates the present status of the X-Bit, with the indicator ON if the X-bit is a zero and OFF if it is a one.
15	DISPLAY ERROR Switch	Pressing the switch selects one of the two error types BIT or BPV if the Measurement Mode is in ERROR-SECONDS, TOT ERR, AVG BER, or BER. The DC MONITOR mode turns off both BIT and BPV indicators and illuminates DCV.
16	(MODE) ERROR-SECONDS TOT and % Switch and Indicators	Total ERROR-SECONDS displays on the ERROR (18) display the number of seconds which had error rates exceeding the threshold selected by the ERROR THRES (23,24) switch. Percent ERROR-SECONDS displays the percentage of seconds during the test which had error rates exceeding the selected threshold. This switch is also used to enter a "4" into the TIME (5) display. Error-seconds may be referenced to 1-second ticks on the clock, asynchronous or a 1-second period starting with the first error called synchronous error-seconds.

Table 3.1 - continued

Reference Symbol	Panel Decal	Functional Description
17	(MODE) TOT ERR and AVG BER Switch and Indicators	Total Errors displays the total number of Bit or BPV errors greater than the selected threshold (23,24). If threshold ALL is selected, then all errors would be displayed. If another threshold is selected, then all errors in seconds where the error rate exceeded the threshold would be displayed. Average Error Rate (AVG BER) is the total number of errors divided by total number of bits. This function will be a running average during a test and at the end of a test, the total number of errors divided by the total number of bits during the test. This switch is also used to enter a "5" into the TIME (5) display.
18	MEASUREMENT Display	These six characters display the current value from the selected error accumulator as determined by the MODE (16-20) and display (15,23,24) switches. It can display the values in decimal form and, when necessary, convert to scientific notation of the form 1.23 E-4. The display range is 0 to 999999, then 1.00E6 to 9.99E50, for total counts. For error rates, the range is 0 to 1.00E-9 to 1.0E-50. For DC volts, the range is +40.00 to -40.00 volts.
19	(MODE) BER-FAST and SLOW Switch and Indicators	When the FAST mode is selected, the Error Rate (BER) display is updated every 0.25 seconds, and in the SLOW mode the update interval is about 2 seconds. These settings may be used to display BER while the timer is stopped. This switch is also used to enter a "6" into the TIME (5) display.
20	(MODE) IN 1- IN 2 DC MONITOR	This switch provides selection of the Input 1 or Input 2 DC MONITOR voltages and DRY CONTACT STATUS to be displayed in the MEASUREMENT (18) Display. In this MEASUREMENT MODE, the first dis-

Table 3.1 - continued

Reference Symbol	Panel Decal	Functional Description
20	(MODE) IN 1- IN 2 DC MONITOR (continued)	play position is always reserved for the DRY CONTACT STATUS (blank = Inactive, A = active, and H = has been active during the timed test) and the remaining positions indicate the input voltage. The two indicators illuminate when their corresponding INPUT is selected. Pressing this switch while holding in the SHIFT (1) switch causes a "7" to be entered in the TIME (5) display.
21	(PRINT) DCV or BER ALL or PART Switch and Indicators	This switch provides selection of the error conditions which will trigger a printout of test data. A printout may be triggered by: a) a DC out-of-threshold error conditon, b) a Bit Error Rate which exceeds the selected ERROR THRESHOLD (23,24), or c) either of these error conditions. The DCV and BER indicators alternate between three states accordingly: a) DCV indicator only, b) BER indicator only, c) both indicators ON. Pressing this switch while holding in the SHIFT (1) switch provides for selection of either ALL or PART formats. The ALL and PART indicators toggle between these two conditions.
22	PRESET TEST Switch and Indicators	This switch allows the saving and recalling of up to 4 different sets of front panel settings. To save a front panel setting, set the front panel to perform the test desired. While holding SHIFT (1) depressed, press CTRL (32), enter a number 1 to 4 using switches with red numbers below, then release SHIFT and press PRESET TEST (22). The front panel settings are stored in memory as Preset Test "X", where X is the number 1-4 entered after CTRL was pressed. To recall a test setup, press PRESET TEST (22) to the

Table 3.1 - continued

Reference Symbol	Panel Decal	Functional Description
22	PRESET TEST Switch and Indicators (continued)	number of the desired test, and the unit will be set to perform that test. If this switch is pressed while SHIFT (1) is held in, a decimal point is entered in the TIME (5) display.
23,24	ERROR THRESHOLD Switch and Indicators	These two switches permit selection of one of the four available thresholds for error measurements: ALL, 10^{-6}, PROG, and 10^{-3}. Each switch toggles selection between the two associated functions. ALL will count all occuring errors. 10^{-6}, PROG, and 10^{-3} will only count errors if the error rate exceeds the selected value. (See Part C.3 of Section 3.4 for programmable threshold). These switches enter numbers "8" and "9" in the TIME (5) display when pressed while holding in SHIFT (1).
25	POWER Switch and Indicator	A two-position switch for turning power ON or OFF to the analyzer. The indicator is ON when power is ON to the unit. The indicator blinks to indicate a power fail condition. It is reset by RESET (26).
26	RESET/CLEAR Switch	Pressing this switch while timer is stopped resets the STATUS-MEMORY (8-11) indicators and the internal error accumulators. Pressing this switch while holding in the SHIFT (1) switch clears the TIME (5) display and de-selects the MODE indicator under the TIME display. Pressing this switch with the timer running, resets timer to initial value (0 for ELAPSED and preset number for REPEAT or SINGLE), resets status indicators, resets Error Counters, and restarts the test with RUN on.

Table 3.1 - continued

Reference Symbol	Panel Decal	Functional Description
27	REMOTE Indicator	This indicator illuminates when front panel controls are disabled and operational commands are being received through an optional external interface, either IEEE-488 or RS-232C.
28	GATING	This indicator illuminates constantly when an ERROR measurement is in progress and flashes when the ERROR display is updated.
29	RUN/STOP Switch and Indicators	Pressing this switch alternately selects between the RUN and STOP modes of timer operation. The switch is necessary for the accumulation of timed errors. Indicator lights for RUN and STOP are positioned above the switch. This switch is also used to enter the number "3" into the TIME (5) display. If the unit is running a test and a DC threshold is exceeded or an alarm occurs, the RUN indicator flashes. The condition is cleared by RESET or RESTART (26).
30	NRZ-INPUT DATA and CLOCK Connectors	These inputs accept BNC-type connectors and have an input impedance of 75 ohms and are DC coupled. They accept external NRZ format DATA and CLOCK for measurements and are intended for use with the optional DS3 to DS2 demultiplexer.
31	CHANNEL Select Switch and Indicators	This switch selects the desired channel or channels on which measurements will be made. In DS1 only channel 1 is used. In DS1C, channels 1 or 2 or both can be selected and in DS2, channels 1, 2, 3, or 4 or all four can be selected. Each push of the switch advances the indicator through the defined single channels. Both DS1C or all four DS2 channels are selected by: (1) Hold SHIFT (1) and press DATA to enter the control mode. Release SHIFT and press

Table 3.1 - continued

Reference Symbol	Panel Decal	Functional Description
31	CHANNEL Select Switch and Indicators (continued)	CHANNEL. Both DS1C or all four DS2 channels will be selected. If the SHIFT (1) is held in and CHANNEL (31) pressed, the sign + or - will: 1) be entered in the TIME (5) display or 2) if already present in TIME (5) display, alternates the value to the other polarity.
32	(INPUT) DATA-PRBS or OTHER Switch and Indicators	This switch selects if the analyzer is to receive the Pseudo-Random Bit Sequence (PRBS) or one of the other data patterns output by the transmitter. If this switch is pressed while SHIFT (1) is held in, the Control Mode is entered.
33	INPUT-DS1, DS1C, DS2-LO/DSX, or DS2-HI Switch and Indicators	This switch selects the type of signal the analyzer is to receive. It is operated to the same setting as the OUTPUT SELECT switches on the transmitter. If this switch is pressed while SHIFT (1) is held in, a lamp test is performed.
34	(INPUT) DS1/1C/2 Connector	This connector accepts a WE-310 type plug and is the receiver input for DS1, DS1C, and DS2 signals.

3.3 REAR PANEL CONNECTORS

Figure 3.2 shows the rear panel of the AC version of a Model 4654A Analyzer and the location of the ten connectors. The AC/DC version has an additional connector for auxilliary DC power source. These connectors are for: (1) the ac power source, (2) the dc power source (on ac/dc models only), (3) the local printer (Model 4650) connector, (4) the remote control features through either IEEE-488 (Part Number 304208) or RS-232C (Part Number 304209), (5) the connector for remote control of the optional Model 4656 DS3 to DS2 Demultiplexer, and (6) the EXTERNAL EVENT MONITOR (Part Number 304210). Also, five BNC-type connectors on the rear panel provide access to DATA, M-SYNC,

PR-SYNC, ERROR, and recovered CLOCK. Each BNC-type connector is isolated by a 50-ohm line driver. Normally, only one of the two possible power sources would be connected at a time although no damage will result if ac and dc power sources are simultaneously applied. The optional data printer is powered and remotely controlled through the rear panel connector. The printer will operate by local control or by commands through remote control. Remote control is identified as being either IEEE-488 or RS-232C depending on which I/O option is installed.

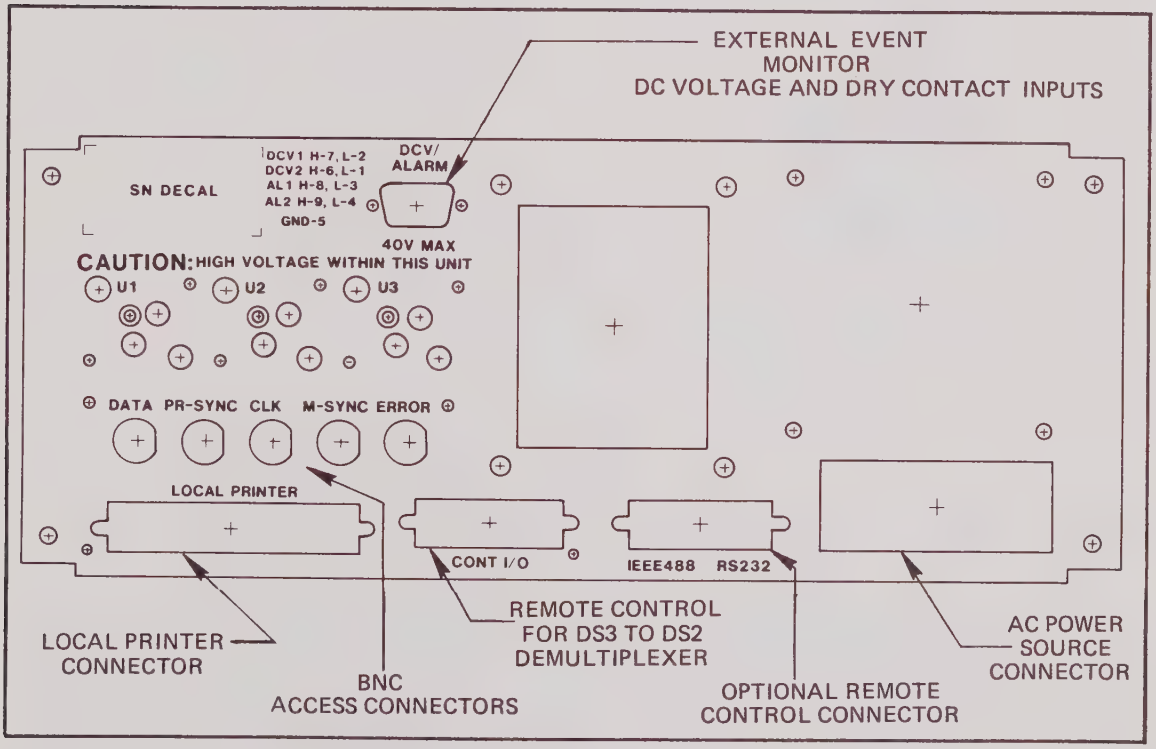


Figure 3.2. Typical Rear Panel Features

The Model 4654A Analyzer operating under remote control, is fully programmable as a talker and listener but cannot be a controller for the IEEE-488 Bus. However, the analyzer may be set up for "talk only" mode operation (for use with an IEEE-488 compatible printer as an example).

3.4 OPERATION - MODEL 4654A ANALYZER

General. Although the operation of the Model 4654A Analyzer has been described in figures and tables, there are some operational modes of complex nature requiring additional operating instructions. These instructions usually pertain to switches requiring a proper sequence to achieve a desired result or the interaction of various switch combinations.

Detailed descriptions for the following switch and/or connector groups are given in the following paragraphs:

A. TIME DISPLAY
B. TIMER MODES
C. MEASUREMENT DISPLAY
D. MEASUREMENT MODES
E. OUTPUT CONNECTORS
F. INPUT CONNECTORS
G. INTERNAL JUMPERS
H. PRINT CONTROL

A. TIME DISPLAY

Front panel indicators above and between switches are Light Emitting Diodes and for purpose of brevity, will be referred to as (a) LED through the remainder of this section. They should not be confused with the seven segment characters used in the TIME and ERROR displays.

The LED's over switches below the TIME display, indicate by associated switch decal the type of time or voltage data currently being displayed. However, if the RUN LED is illuminated, the MODE LED may not properly indicate the timed test timer operating mode. For example, TIME OF DAY may be selected for the TIME display while an ELAPSED or a TIMED test is running. The TIME display indicates the time of day while the selected timer continues to run. As a second example, ELAPSED time can be displayed if a TIMED countdown test is running; but SINGLE-TIMED or REPEAT-TIMED modes cannot be displayed while an ELAPSED test is in process. The MODE LED indicators return to the actual timer operating mode if the RUN/STOP switch is pressed, illuminating STOP LED, and pressed again, illuminating the RUN LED. If the TIME display indicates

either the TIME OF DAY or an ELAPSED time function while the REPEAT mode is enabled, when the repeat timer counts to 0 and a new cycle is started, the TIME display is pre-empted to present the new cycle REPEAT countdown. The REPEAT LED is illuminated to alert the operator that one REPEAT cycle is complete.

In the DC THRESHOLD mode, the TIME display is used to display voltages. DC voltages from -40.00 to +40.00 volts may be entered as high or low thresholds for each of two DC VOLTAGE inputs. Two decimal place fixed-point notation is used when a voltage is entered. For example, 12.5 volts is changed to 12.50 volts upon leaving the SET MODE (Note: the decimal point must be entered explicitly).

1. MONTH-DAY Switch

When the MONTH-DAY switch is pressed, the TIME display indicates the current month and day as determined by the internal real-time clock. The month and day are displayed in the TIME minutes and seconds locations for several seconds and then display returns to the previous display mode.

2. TIME OF DAY Switch

When the TIME OF DAY switch is pressed, the TIME display indicates the time of day as determined by the internal real-time clock. The TIME display indicates "hours:minutes:seconds" in a 24-hour format. The TIME OF DAY may be selected during an ELAPSED or TIMED test without affecting the measurement.

3. Resetting Clock Functions

The front panel SHIFT switch performs a function analogous to the shift key on a typewriter. Normally, the switches respond with the functions labelled above them. When the SHIFT switch is pressed, the shift function is enabled and other switches respond to the function below them while the SHIFT

switch is depressed. Resetting the clock functions consists of five basic steps using "beneath the switch" decals.

NOTE

A flashing LED indicates the SET MODE, values can only be changed from the STOP Mode, and except for the MONTH-DAY mode, only the value corresponding to the illuminated LED can be changed. An invalid set or sequence causes an exit from the SET MODE. Resetting values in the TIME display consists of the following four basic steps:

1. Press appropriate switch to illuminate LED of TIME MODE or DC THRESHOLD to be set. This step is not necessary for setting MONTH-DAY.

2. Press and hold SHIFT switch.

3. Enter desired numbers (± or . too if appropriate). The LED flashes (except for MONTH-DAY).

4. If setting MONTH-DAY or TIME OF DAY, then press the desired switch to lock in the numbers and then release the SHIFT switch. The TIME-OF-DAY LED stops flashing if TIME-OF-DAY was entered.

4A. If setting ELAPSED, SINGLE or REPEAT TIMED, or DC THRESHOLD, then release the SHIFT switch and then press the switch under the flashing LED to lock in the numbers. The LED stops flashing.

a. Resetting Time of Day

Perform the following sequence:

1. Press TIME OF DAY switch.
2. Press and hold SHIFT switch.
3. Enter desired numbers in 24-hour clock format [i.e., 14 (hours) 35 (minutes) 00 (seconds)].
4. To load and start the clock, press TIME OF DAY switch.
5. Release SHIFT switch.

b. Resetting Month-Day

Perform the following sequence:

1. Press and hold SHIFT switch.
2. Enter desired numbers for month and day.
3. Press MONTH-DAY switch.
4. Release SET switch.

c. Setting Timer Modes

Perform the following sequence:

1. If necessary, operate RUN/STOP switch to STOP.
2. Select desired TIMER mode.
3. Press and hold SHIFT switch.
4. Enter desired numbers for SINGLE TIMED or REPEAT TIMED test. A 00 is usually used for ELAPSED test. (Note the LED now flashes to indicate SET MODE.)
5. Release SHIFT switch.
6. Press timer mode switch corresponding to flashing LED.
7. Press RUN/STOP switch to RUN to start the timer.

d. Setting DC Threshold

DC Thresholds are entered in the same way as timed test times. The ± and decimal point switches may be used. Only two decimal places are allowed.

e. Invalid Time Entry

An invalid sequence or entry causes an exit from the SET Mode and an error message to appear momentarily in the MEASUREMENT display.

4. Display at Power-Up

When the Model 4654A analyzer is powered on, it will display "OPt" in the hours location of the Time display. This indicates that the unit is searching for any installed options. An "A" or "S" (looks like a 5) will appear in the tens-of-minutes digit. This indicates that the unit is set to measure synchronous (S) or asynchronous (A) error-seconds. (See Section D. MEASUREMENT MODES.) If software for the optional printer, remote interfaces, or External Event Monitor is installed, one or more numbers will appear in the minutes digit, and a two letter code for each option installed will appear in the

error display: Pr = Printer, rE = Remote Interface, dc = External Event Monitor. If a remote interface PCB is installed in the unit, the RS-232C Baud Rate or IEEE-488 address will be indicated in the seconds digits.

The microprocessor then checks the CRC of the nonvolatile RAM. If the calculated CRC does not agree with the value stored in the RAM, "CrC Er" will be displayed in the Error display for several seconds. The unit will then automatically perform a "Pristine Reset"; all parameters will be set to their default state. If there is no CRC error, a lamp test will be performed.

B. TIMER MODES

General. The Timer Modes operate in conjunction with the TOT ERR, ERROR SECONDS, and AVG BER switch selected modes since these error measurements require a time reference. For example, 10 ERROR-SECONDS has no meaning unless the time period over which the errors occurred is known, such as 10 seconds, 15 minutes, 8 hours, 5 days, etc. Similarly, the TOT ERR mode must be referenced to a test period. A better understanding that the AVG BER mode yields the averaged Bit Error Rate (BER) for the test period is possible with a known time frame. When the RUN/STOP switch is operated to RUN, all errors, bit and bipolar code violations (BPV) are accumulated simultaneously regardless of the error type or error mode selected for display (except burst data). For example, AVG BER may be selected while running a timed test without affecting the error accumulators for the timer measurements. Also after the test, the ERROR display can be switched between any mode without affecting the error count.

1. ELAPSED Time Test Mode

Normally, the ELAPSED time test mode would be started at display TIME of 00 because in this mode the timer counts up to 999:59:59 maximum unless the operator stops the test. Pressing the RUN/STOP switch starts and stops the timer. If no previous time test mode has been selected, and the analyzer is initially powered by operating the front panel POWER ON switch, the analyzer is configured to the same settings as at power-down, stored previously in the

non-volatile RAM. Then if the RUN/STOP switch is operated to RUN, the TIME display automatically resets to :00, the ELAPSED time mode panel indicator illuminates, and the internal timer starts counting up. Otherwise, you must CLEAR the TIME display and select ELAPSED mode before pressing the RUN switch. The display can be switched to TIME OF DAY without disturbing the ELAPSED timer. An initial offset can be loaded into the timer before selecting ELAPSED. This loading will not preload the TOTAL BITS counter to correspond to the entered offset. The TOTAL BITS value corresponds to the length of time the RUN indicator is illuminated.

2. SINGLE-TIMED or REPEAT-TIMED Test Mode

To initiate a preset internal timed test, first enter the desired time as described earlier. Then press either the SINGLE-TIMED or REPEAT-TIMED switch without holding the SHIFT switch depressed. When the RUN mode is selected now, the timer will count down to 0 and stop if the SINGLE-TIMED mode has been selected, or the timer will continually repeat until stopped, if the REPEAT TIMED mode has been selected. For a 10-second repeat test, the TIME display counts from 9 to 0 rather than from 10 to 1. If a 1-second repeat test is started, the TIME display indicates a continuous 0 since the 0-second is repeated. A 1-second REPEAT-TIMED test is convenient to display TOTAL ERRORS on a 1-second update rate.

Selecting between ELAPSED, TIME OF DAY, and MONTH-DAY displays while running a timed test without disturbing the count-down timer is also possible. During this mode, the ELAPSED command causes the TIME display to indicate the length of time so far completed of the timed test, while the SINGLE-TIMED or REPEAT-TIMED modes indicate the time to completion of the test. Timer modes can be switched any time between SINGLE and REPEAT without affecting operation of the timer or length of test while operating in the RUN mode. Only when the TIME display indicates 00 is a determination made to repeat the cycle, if in the REPEAT-TIMED mode, or to stop at 00 if in the SINGLE-TIMED mode. If during a timed test the ELAPSED mode is selected, then the previously-selected mode (either SINGLE-TIMED or REPEAT-TIMED) determines whether the cycle stops or repeats at 00.

C. MEASUREMENT DISPLAY

The DISPLAY switch selects the error type (BIT or BPV) or voltage indicated on the MEASUREMENT display. When the RUN indicator is illuminated, both error types are simultaneously counted in all error modes except BURST. BURST is only counted for the error-type selected at start of test. Each error type is individually accumulated and stored for all thresholds and is available for recall and display on command.

The DISPLAY ERROR switch, in conjuction with the two ERROR THRESHOLD switches, selects a desired measurement for display. The DC Monitor switch selects the desired DC input for display. In this mode, the first display position is always reserved for the DRY CONTACT status (blank = Inactive, A - Active, H = has been active during the timed test). The remaining positions indicate the input voltage in two decimal place fixed point notation.

1. RESET Switch

When the analyzer is in the STOP mode, pressing the RESET switch clears the internal counters for ERROR-SECONDS, TOT ERR, and AVG BER for each Threshold plus the Burst Counters. Pressing the RESET switch also clears the STATUS-MEMORY indicators. These indicate at some time since the last RESET was pressed, the identified subject was lost and regained (the indicators flashing for the memory function are also cleared). Pressing the CLEAR function (SHIFT-RESET), clears the TIME display. When the analyzer is in the RUN mode, pressing the RESET switch (either shifted or non-shifted) accomplishes a RESTART of the test as described in these statements:

- The timer is reset to its initial value
- Status indicators are reset
- The STOP LED illuminates
- "START" appears in the MEASUREMENT display
- The test then restarts with the RUN LED on.

2. "PRISTINE RESET" Function

The non-volatile memory in the 4654A is very convenient in case of accidental power loss. However, to permit simple reset to a known state, a "pristine reset" function is available. This reset is accomplished from the STOP mode by initiating a lamp test provided at power-up, then pressing the RESET button during the lamp test. The lamp test lasts longer than usual, as all registers and state varibles are reinitialized. The resulting default modes are shown in the following list:

- TIME-OF-DAY TIME DISPLAY
- STOP MODE
- DISPLAY BIT ERRORS
- ERROR THRESHOLD: ALL
- FAST BER
- PRINT CONTROL: ALL BER
- INPUT: DS1
- PRBS
- NON-REMOTE (LOCAL)
- DC THRESHOLD: ±40.00V (if External Event Monitor option is installed)

3. MEASUREMENT Display

The MEASUREMENT display provides a range of 0 to 999,999 in fixed notation and 1.00E06 to 9.99E50 in scientific notation. The range is -40.00 to +40.00 for a dc voltage.

The DISPLAY ERROR and DC MONITOR switches control display selection of errors or voltages. When the DC MONITOR switch is pressed, the present DC voltages and alarm conditions are displayed. The DCV indicator illuminates indicating a voltage presence in the MEASUREMENT display. When selecting one of the error modes, either BIT or BPV indicators illuminate and the data for that particular error type and selected threshold appears in the MEASUREMENT display. Each operation of DISPLAY ERROR alternates the MEASUREMENT display between BIT and BPV errors.

In the thresholds, errors are only counted if the BER for that particular second is greater than the selected threshold. Error data is accumulated for

all thresholds while a test is running; the ERROR THRESHOLD switch only selects which data will be displayed.

Any threshold may be examined during or after a test without affecting the data accumulation. The PROG function allows the user to program a threshold error rate of 1 x 10^{-7} to 9.99999 x 10^{-2}. If this function is programmed to "0", it will perform the same as the "ALL" threshold. This function is programmed by holding the SHIFT switch depressed, pressing CTRL (DATA Switch), entering the desired number (0-999999), releasing the SHIFT switch, and pressing the ERROR THRES switch. The ERROR display will momentarily display "SAVED". The desired threshold is determined by the entered number times 10^{-7}. For example, an error threshold of 2 x 10^{-5} is programmed by entering a 200 (2 x 10^{-5} = 200 x 10^{-7}). This allows any error rate threshold in the range stated above, to be programmed. When the ERROR THRES switch is pressed to the PROG position, the ERROR display will momentarily display the programmed threshold (0-999999) before displaying the error data. The number of errors per second needed to exceed the thresholds is given in Table 3.2

Table 3.2
Errors/Sec Needed to Exceed Threshold

Signal	RATE (MBit/sec)	THRESHOLD			
		All (0)	10^{-6}	PROG	10^{-3}
DS1	1.544	1	2	1	1545
DS1C	3.152	1	4	to	3153
DS2	6.312	1	7	631,200	6313

D. MEASUREMENT MODES

1. Timed Error Counts

The three error measurement modes identified as ERROR-SECONDS, TOT ERR, and AVG BER require operation of the timer in either an ELAPSED (count-up) mode or as SINGLE-TIMED or REPEAT-TIMED (count down) mode. These functions require a timer reference as a base for the measurement. When the RUN indica-

tor is illuminated, these error types are each being counted in separate counters. Any ERROR-MODE switch may be selected for the MEASUREMENT display without affecting the counter. In effect, the MODE switch selects the counter for display.

Each second errors occur (exceeding the selected threshold such as bit and/or bipolar violation) is termed an ERROR-SECOND; the two separate counters would be incremented by the respective error-type causing the error-second. Error-seconds can be displayed as the total number having occurred for each threshold, or as the percentage of seconds that were error-seconds for each threshold since the test began. Error-seconds can be measured in two ways. Synchronous error-seconds are one-second intervals beginning at the occurrence of the first error, and asynchronous error-seconds are referenced to one-second ticks of the Real-Time Clock. Figure 3.3 shows a comparison of the two approaches.

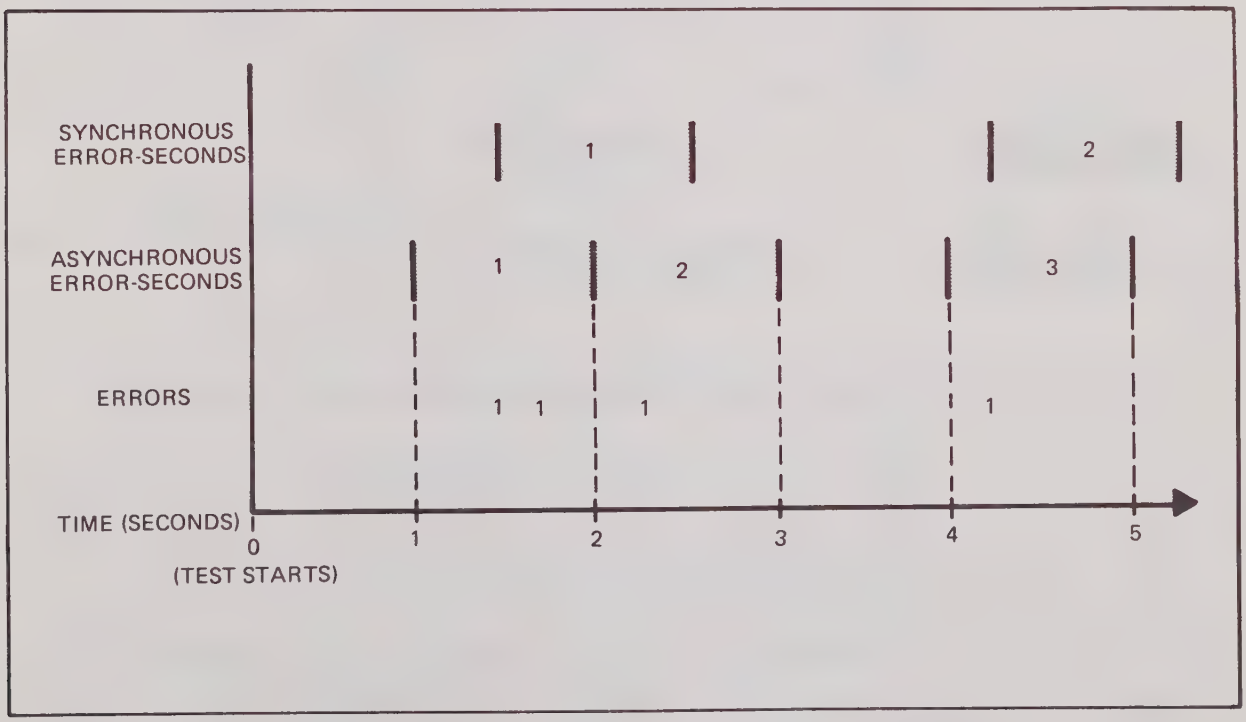


Figure 3.3. Synchronous and Asynchronous Error-Second Comparison

Each of these approaches has special characteristics and merits. The main claims for synchronous error-seconds are: (1) minimization of error-seconds for a given pattern of errors, and (2) the same number of error-seconds for a pattern of errors, independent of when the test was started. By contrast, the asynchronous method can have results different from synchronous error-seconds, or even another asynchronous error-seconds test started at a slightly different time, as shown in Figure 3.4. Synchronous or asynchronous error-seconds mode is selected by a jumper on the Error Counter PCB (A5) as shown in Figure 3.11.

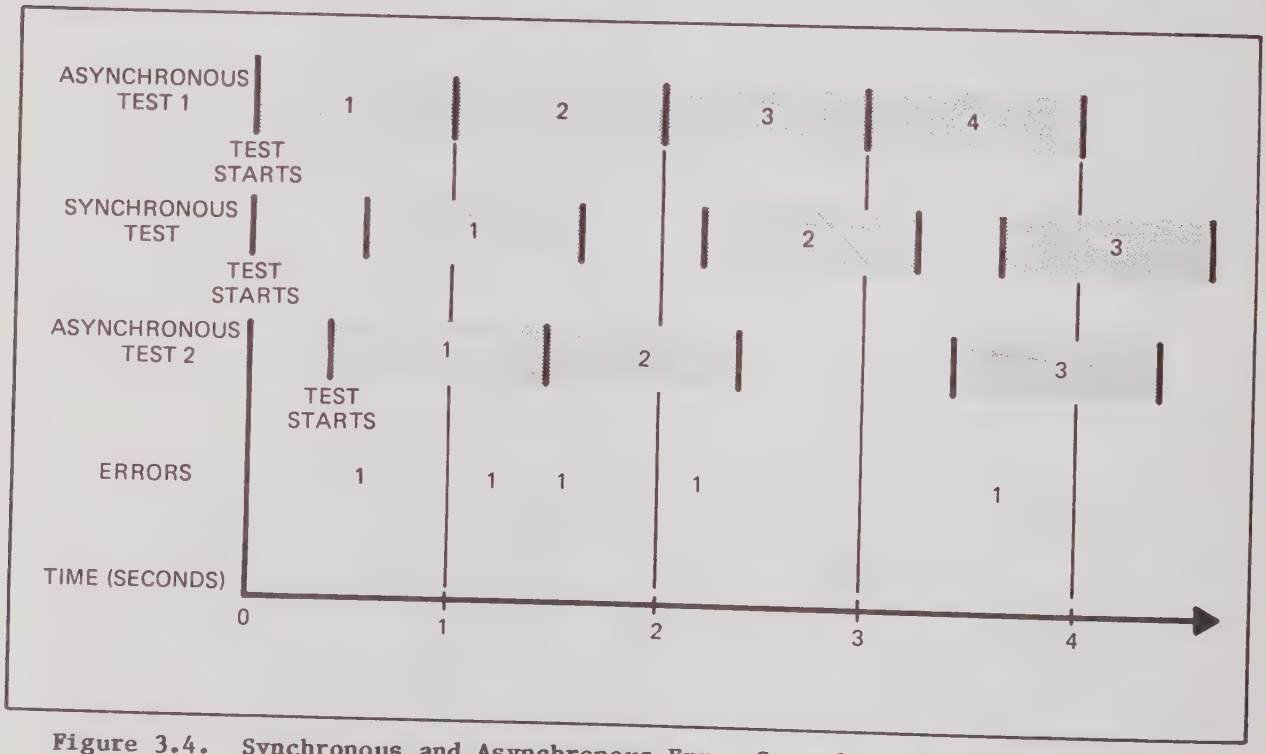


Figure 3.4. Synchronous and Asynchronous Error-Second Test Characteristics

The TOTAL ERRORS function is the total accumulation of errors of each type which have occurred during the timed test for the ALL threshold. For other thresholds, TOTAL ERRORS is the total of errors from errored second which exceeded the threshold. The AVG BER function is the cumulative averaged error rate over the measured time interval. While the timer is running, the time reference measurements are updated on the MEASUREMENT display each second. The internal accumulators are reset or cleared when any one of the following conditions is encountered: (1) the analyzer is in the STOP mode and

RESET is pressed, or (2) the analyzer is in the STOP mode and a new preset test is selected, or (3) the analyzer is in the RUN mode and RESTART is pressed, and finally (4) when a Repeat Timed Test reaches time "zero".

2. Instantaneous Measurements

Switch selectable measurement rate labeled FAST-BER and SLOW-BER display the BER (Bit Error Rate) for Bit or Bipolar Violation (BPV) errors for an approximately 0.25-second update interval in the FAST MODE or 2-seconds in the SLOW MODE.

E. OUTPUT CONNECTORS

Five BNC-type connectors on the rear panel provide signals to other peripheral equipment of the user's choice. All output signals are TTL levels from 50-ohm drivers. The CLOCK output signal is the clock extracted from the input signal. FRAME sync provides a pulse each framing bit for DS1 and a pulse each M-Frame (M1-bit) for DS1C and DS2. PR-SYNC provides a pulse synced to the pseudo-random sequence, occurring when the 20-stage shift register contains a one in the first stage and 19 zeros. ERROR provides output of the selected errors (Bit or BPV). DATA provides access to the NON-B6ZS data.

F. INPUT CONNECTORS

1. NRZ CLOCK and DATA

Input data in NRZ (Non-Return to Zero) format having the proper framing bits, can be applied through the NRZ DATA connector directly to the Model 4654A Analyzer circuits bypassing the Clock Recovery circuit.

2. DS1/1C/2 Input Connector and Associated Switches

The DS1/1C/2 data input connector is compatible with WE type 310, or equivalent. The INPUT select switch chooses whether the analyzer is operating in DS1, DS1C, DS2-LO/DSX, or DS2-HI mode. The LEDS will advance through this

sequence one position each time the switch is pressed. This switch operates to correspond to the OUTPUT SELECT switch setting on the transmitter. The DATA Switch selects the type of data to which the analyzer will synchronize. Each time it is pressed, the LEDS alternate between PRBS and OTHER. PRBS (Pseudo-Random Bit Sequence) is the $2^{20}-1$ data sequence the transmitter outputs when the DATA-PRBS switch on it is depressed. OTHER is used for any of the other bit patterns that the transmitter can generate. The CHANNEL switch is used to select which data channel will be monitored. Each time the switch is pressed, the LEDS advance one position through the sequence. In DS1, only one channel and position (1) should be used. In DS1C, positions 1 or 2 can be used to monitor each channel separately or both together. Similarly, with DS2, channel 1, 2, 3, or 4 can be monitored separately or all four channels together can be monitored. SHIFT must be held depressed to access both DS1C channels or all four DS2 channels. When the unit is operated unframed or framing is lost, the channel select defaults to all channels in DS1C or DS2. This is because channels do not exist without framing.

No switching is provided or required to operate with either DS1/1C/2 input or NRZ inputs; but only one type of input can be connected at a time for proper operation.

3. External Event Monitor Inputs

Two DC VOLTAGES and two DRY CONTACT inputs (located on the rear panel) can be monitored. This connector is shown in Figure 3.5.

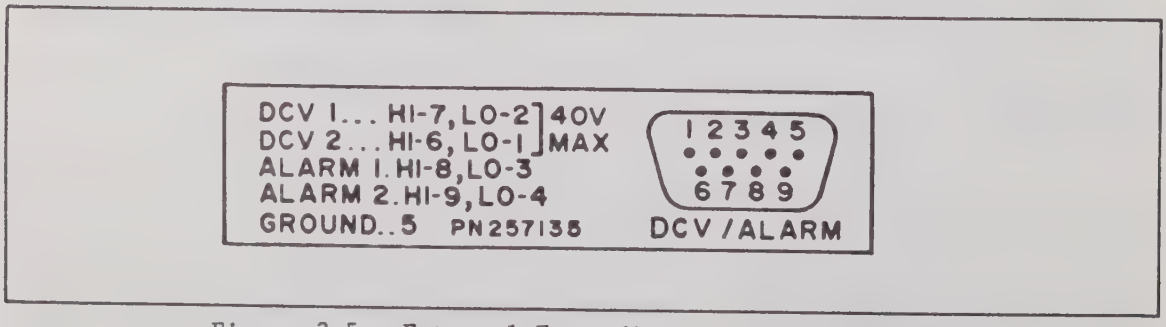


Figure 3.5. External Event Monitor Input Connector

G. INTERNAL JUMPERS

Several rarely-changed operating modes are selected by jumpers or switches located on the PWBs. Two of these modes are IEEE-488 Bus Address and RS-232C Baud Rate (see Figures 3.9 and 3.13). Two other modes also jumper-selectable are DS1 Framing Enable and whether Zero Suppression is used on the PRBS data pattern. On the DS1 Framing PWB (A7), a jumper tells the analyzer to expect framed or unframed DS1, either at the DS1 rate or multiplexed up to DS1C or DS2 (see Figure 3.6). (Note: Jumpers in both Transmitter and Receiver must be set to the same state.)

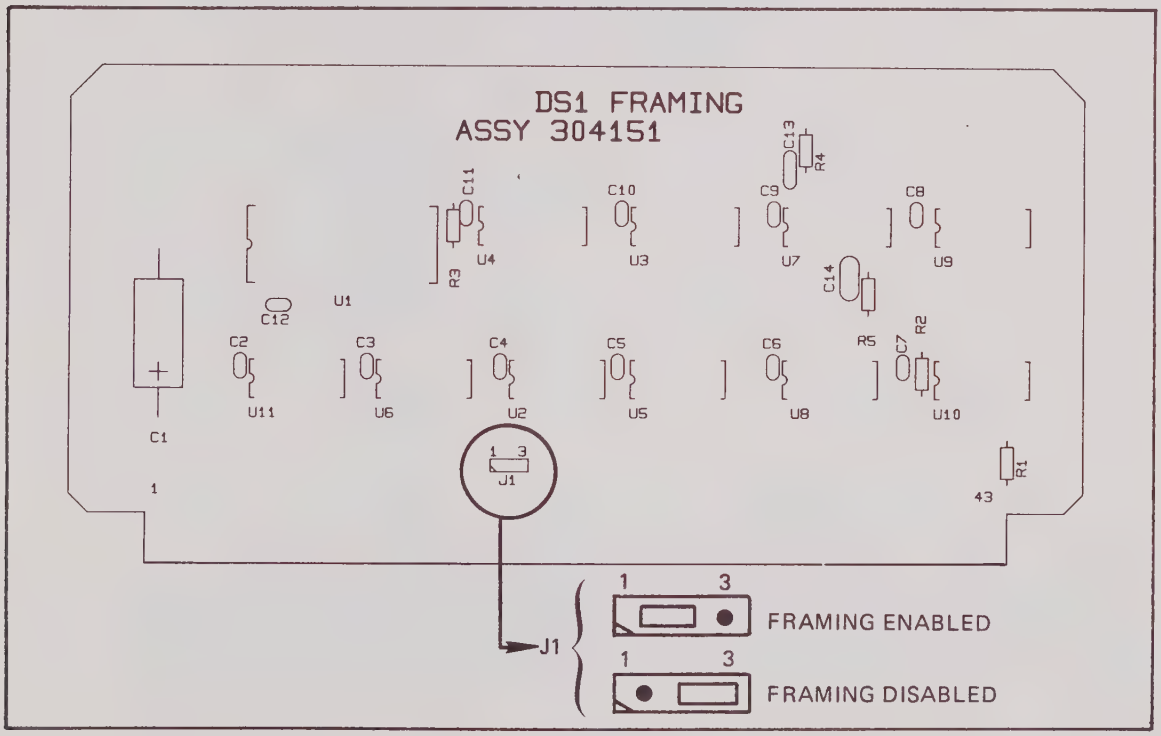


Figure 3.6 Location of DS1 Framing Select Jumper.

Also jumper-selectable is Zero Suppression. In DS1 or in framed DS1C or DS2 mode, the Zero Suppression is controlled automatically, and determined by whether DS1 is framed (14-zero suppression used) or unframed (15-zero suppression used). However, when the unit is operated in unframed DS1C or DS2, the Zero Suppression is manually selectable to 15-Zero Suppression or no suppression. This selection is made by the jumper on J1 of the Bit Error Detector PWB (A6) as shown in Figure 3.7.

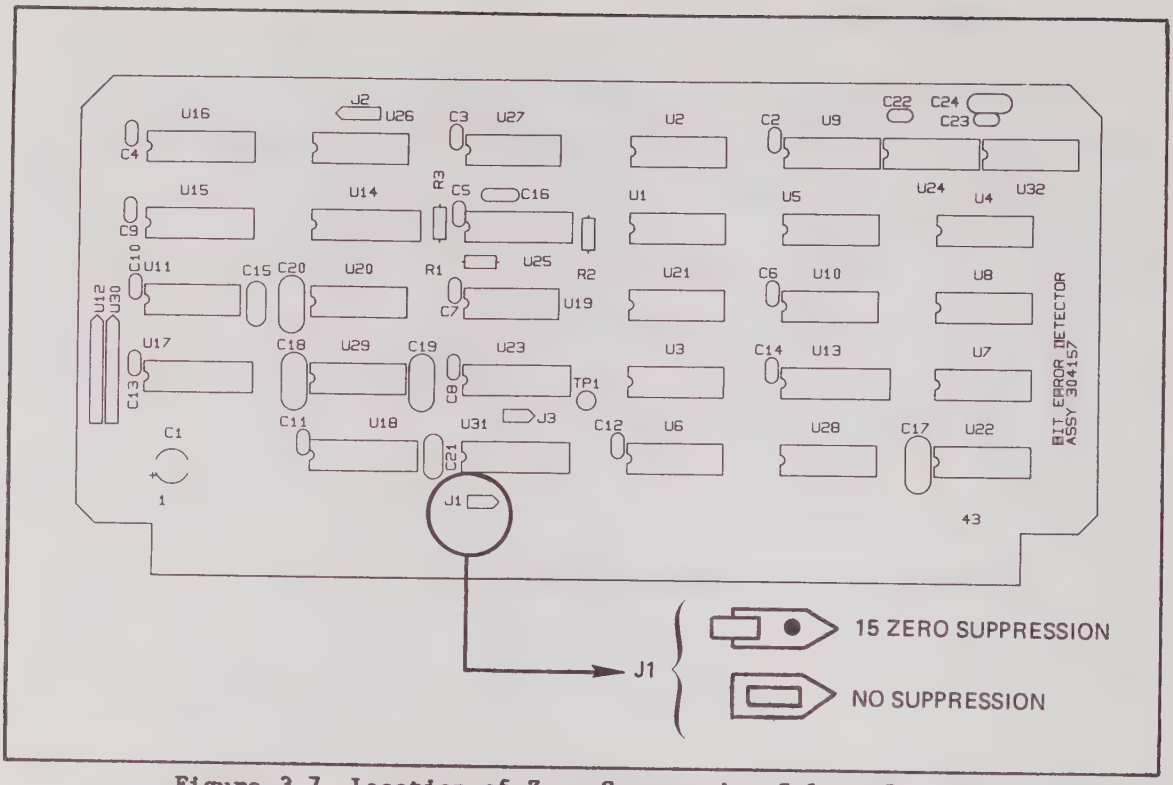


Figure 3.7 Location of Zero Suppression Select Jumper.

H. PRINT CONTROL

1. Triggered Printout

The PRINT CONTROL DCV/BER switch directly selects how a printout is triggered and indirectly selects what data is printed according to Table 3.3. Note that BER Data is always printed.

Table 3.3
Conditions That Will Trigger Printouts

	Trigger on DCV (DCV LED on)	Trigger on BER (BER LED on)	Trigger on Either (Both LEDs on)
DCV Data Printed	√	X	√
BER Data Printed	√	√	√

2. Forced Printout

Pressing the INPUT switch while the SHIFT switch is also pressed produces a Test Result Printout on the Local Printer. This function is available both during and after tests.

3. Printout Format

When pressed with the SHIFT switch held in, the PRINT CONTROL switch controls the format of the message from the local printer. If the ALL LED is illuminated, then the printer will log all errors in all thresholds along with BURST measurements if the ALL ERROR THRESHOLD is selected. If a threshold other than ALL is selected, only data for the "ALL" threshold and the selected threshold will be printed. If the PART LED is illuminated, then only errors in the selected threshold are displayed.

I. ADDITIONAL FUNCTIONS

The following paragraphs are a summary of the LEDs which blink and the significance of their blinking.

1. A blinking TIME-OF-DAY, ELAPSED, SINGLE, REPEAT, HI DC THREHSOLD, or LO DC THRESHOLD LED signifies SET MODE has been entered and the operator is expected to: (a) enter more numbers into the TIME display, (b) exit the SET MODE by pressing the switch under the blinking LED (SHIFT must be pressed in to enter TIME-OF-DAY switch while holding in the SHIFT switch, thus entering the numbers in the display as the month and day.

2. The GATING LED blinks when the display is updated with new information.

3. The status LEDs IN 1 and IN 2 DC THRESH blink after a test has been stopped to indicate their status condition occurred at some time during the timed test.

4. A blinking RUN LED indicates at some time during the test a DC Input went out of threshold or one of the dry contact monitors has detected an alarm.

5. A blinking POWER LED indicates that a POWER LOSS has occurred.

3.5 OPERATION - MODEL 4650 PRINTER

A. GENERAL

The Model 4650 Printer is an option and, when provided, can make permanent records of measured results. The Model 4650 Printer can be operated in one of two different modes to facilitate error logging. These modes can be identified with either the ELAPSED or TIMED modes of the Model 4654A Analyzer. During the ELAPSED mode, errors will be logged whenever they occur. During a TIMED mode, errors will be logged whenever the receiver timer counts to 0. If timed tests are less than 1-hour error, logging occurs only at 0, but status changes are logged. For timed tests 1 hour or longer, errors are logged as they occur, as well as at 0. If, in either mode, a SIGNAL LOSS, DATA LOSS, FRAME LOSS, EXCESS ZEROS, DC INPUT out of threshold, or DRY CONTACT MONITOR status change occurs, the time when the condition occurred and the time when the signal or frame was recovered will both be logged.

B. INSTALLATION

The Model 4650 Printer receives operating power and command signals through the provided Interface cable, connected to a Model 4654A Analyzer. Operate the analyzer POWER switch OFF (down position) before attaching the interface cable to the rear panel connector labeled "LOCAL PRINTER". The Model 4650 Printer may be placed on top of or beside the Model 4654A Analyzer, leaving sufficient space around it to allow normal paper feed through the printer.

C. OPERATION

1. Self-Test Mode

If the Model 4650 Printer is to be used after a period of storage or if a self-check is desired following relocation, use the following procedure:

a. Apply power to the associated Model 4654A Analyzer.
b. Operate the Model 4650 Printer POWER switch to OFF.

c. Press and hold PAPER ADVANCE switch, then operate printer POWER switch to ON. The printer will provide a full character set as a self-test.
d. Release PAPER ADVANCE switch.

2. Log When Errors Occur

Set up the Model 4654A Analyzer to make an ELAPSED time test as described in Section 3.4. After this is accomplished, and when the analyzer STOP indicator is illuminated, operate the Model 4650 Printer POWER switch to ON. Now operate the Model 4654A Analyzer to RUN. This starts the analyzer timer and whenever an error occurs the time will be logged. The error types are totaled and printed using any of the measurement modes. A typical message printout is shown in Figure 3.8.

Several features are provided to avoid printing superfluous readings during SIGNAL LOSS, FRAME LOSS, or other high error rate conditions. If, for example, SIGNAL LOSS or FRAME LOSS occur, then no other mesurements are logged until the error condition is removed. The time the SIGNAL LOSS or FRAME LOSS event occurred will be logged as well as time of SIGNAL and FRAME recovery. Also, if the error rate is sufficiently high to cause 40 consecutive error seconds, then the logging is changed to occur at a fixed rate of every 5 minutes to avoid excessive printouts which contain little useful information. Within 5 minutes after the error condition is corrected, logging features return to log on each error as before, provided the last 40 seconds in the 5-minute period are error-free. In printouts generated during a test, the AVG BER measurement is actually the worst 1-second average since the last printout.

3. Log on Preset Interval

Set up the Model 4654A to make a SINGLE-TIMED and REPEAT-TIMED test as described in Section 3.4. When the analyzer STOP indicator is illuminated, operate the Model 4650 POWER switch to ON. Operate the Model 4654A to RUN. Each time the timer counts to 0 a new log is made. During the SINGLE-TIMED mode, only one log will be made; and during the REPEAT-TIMED mode, logs will be made at each 0 count until timer is stopped. SIGNAL LOSS, FRAME LOSS and

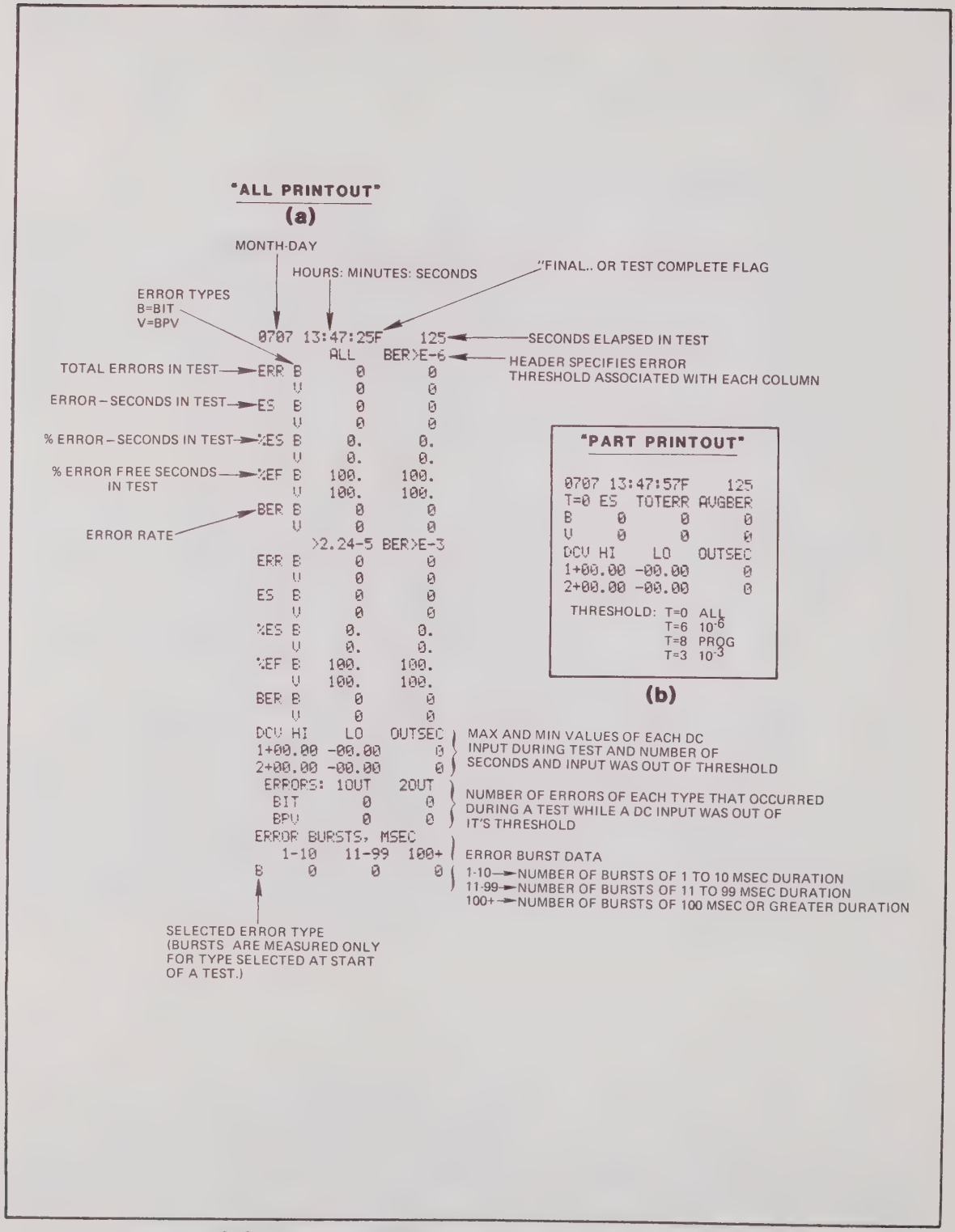

"ALL PRINTOUT"
(a)
MONTH-DAY
HOURS: MINUTES: SECONDS
"FINAL.. OR TEST COMPLETE FLAG
ERROR TYPES
B=BIT
V=BPV
0707 13:47:25F 125
SECONDS ELAPSED IN TEST
ALL BER>E-6
HEADER SPECIFIES ERROR THRESHOLD ASSOCIATED WITH EACH COLUMN
TOTAL ERRORS IN TEST
ERR B 0 0
V 0 0
ERROR-SECONDS IN TEST
ES B 0 0
V 0 0
% ERROR-SECONDS IN TEST
%ES B 0. 0.
V 0. 0.
% ERROR FREE SECONDS IN TEST
%EF B 100. 100.
V 100. 100.
ERROR RATE
BER B 0 0
V 0 0
>2.24-5 BER>E-3
ERR B 0 0
V 0 0
ES B 0 0
V 0 0
%ES B 0. 0.
V 0. 0.
%EF B 100. 100.
V 100. 100.
BER B 0 0
V 0 0
DCU HI LO OUTSEC
1+00.00 -00.00 0
2+00.00 -00.00 0
MAX AND MIN VALUES OF EACH DC INPUT DURING TEST AND NUMBER OF SECONDS AND INPUT WAS OUT OF THRESHOLD
ERRORS: 1OUT 2OUT
BIT 0 0
BPV 0 0
NUMBER OF ERRORS OF EACH TYPE THAT OCCURRED DURING A TEST WHILE A DC INPUT WAS OUT OF IT'S THRESHOLD
ERROR BURSTS, MSEC
1-10 11-99 100+
B 0 0 0
ERROR BURST DATA
1-10 → NUMBER OF BURSTS OF 1 TO 10 MSEC DURATION
11-99 → NUMBER OF BURSTS OF 11 TO 99 MSEC DURATION
100+ → NUMBER OF BURSTS OF 100 MSEC OR GREATER DURATION
SELECTED ERROR TYPE (BURSTS ARE MEASURED ONLY FOR TYPE SELECTED AT START OF A TEST.)
"PART PRINTOUT"
0707 13:47:57F 125
T=0 ES TOTERR AVGBER
B 0 0 0
V 0 0 0
DCU HI LO OUTSEC
1+00.00 -00.00 0
2+00.00 -00.00 0
THRESHOLD: T=0 ALL
T=6 10-6
T=8 PROG
T=3 10-3
(b)

Figure 3.8. Message Printouts from a Model 4650 Printer

DATA LOSS errors are logged as described in Section 2 above. If the REPEAT-TIMED mode is selected with a cycle time of five seconds or less, some logging intervals may be skipped. For TIMED tests 1 hour or longer, errors will be logged when they occur, as well as for 0.

4. Log Formats

The PRINT DCV/BER and ALL/PART switch on the Model 4654A, in conjunction with the ERROR THRESHOLD switch, controls the quantity and format of the data printed in each logging operation, see Section H: PRINT CONTROL. Figure 3.8a is the result of a Print command with PRINT ALL elected and an ERROR THRESHOLD for ALL. In this mode, the entire measurement repertory is printed: all measurements, all thresholds. If one of the other ERROR THRESHOLDs were selected, only the ALL and the selected threshold data would be printed.

Figure 3.8b is the result of a Print command with PRINT PART selected. Only data pertaining to the selected error threshold is printed. Burst measurement information is not printed.

3.6 REMOTE OPERATION

A. GENERAL

The Model 4654A is available with two different remote interface options: IEEE-488 and RS-232C. Although they are physically different, the commands available to the programmer are the same. Differences do arise, however, with interface dependent commands. A GET or a Parallel Poll are physically impossible for RS-232C but are valid commands for IEEE-488. Commands and features valid for only one of the interface options are noted in the text and tables. Only one interface at a time may be installed in the analyzer.

Table 3.4 lists the code assignments for a Model 4654A operating under remote control. Each command consists of several ASCII characters followed with a valid delimiter. Valid delimiters are commas, semicolons, carriage return (CR), and line feed (LF). Before using the following commands, become familiar with the interface standard. Ensure the interface is properly installed.

Table 3.4
Remote Operation Input Command Definitions

Code Letter	Function Title	Descriptions and Subfunctions "n" (where "n" is identified by a number)
Cn	Clear	C1 = Clear Timer C2 = Clear Accumulators C3 = Both (C1 and C2)
CHn	CHANNEL Select (Note 1)	CH1 = Channel 1 CH2 = Channel 2 CH3 = Channel 3 CH4 = Channel 4 CH5 = Channels 1 and 2 CH6 = Channels 1, 2, 3, and 4
CL	Device Clear	Clears the remote interface.
Dn	Select ERROR Type	D1 = BIT Error D2 = BIPOLAR VIOLATION Error
DCn	DS3-DS2 Demultiplexer Channel	DC0 = Return Demux to Local Mode DC1 = Channel 1 DC2 = Channel 2 DC3 = Channel 3 DC4 = Channel 4 DC5 = Channel 5 DC6 = Channel 6 DC7 = Channel 7
DSn	DS3-DS2 Demultiplexer Input Signal	DS1 = LO/HI Signal DS2 = DSX-3 Signal
DTn	DATA Type Select	DT1 = PRBS DT2 = OTHER
En	Select RS-232C Echo	E1 = Echo Off E2 = Echo On (Does not affect IEEE-488 Operation.)
FP	Force Print	Forces a printout on the local printer.
GL	Enable Front Panel	Allows the front panel keyboard to be active (default state). Does not affect IEEE-488 Operation.

Table 3.4 - continued

Code Letter	Function Title	Descriptions and Subfunctions "n" (where "n" is identified by a number)
Hn	INPUT Signal Select	H1 = DS1 H2 = DS1C H3 = DS2 - LO/DSX H4 = DS2 - HI
Jn	RUN/STOP	J1 = STOP J2 = START J3 = Start Standard ELAPSED Test (Note 2) J4 = Start Standard TIMED Test (Note 3)
Kn	Parallel Poll Configuration	K1 through K8 assign parallel poll to bits 1 through 8, respectively. Does not affect RS-232C Operation. KØ clears all bits.
LL	Disable Front Panel	Disables the front panel keyboard. Does not affect IEEE-488 Operation.
Mn	ERROR Display Mode	M1 = TOTAL ERROR-SECONDS M2 = % ERROR-SECONDS M3 = TOTAL ERRORS M4 = AVERAGE BER M5 = FAST BER M6 = SLOW BER M7 = DC MONITOR IN 1 M8 = DC MONITOR IN 2
N	Enter Time or DC Threshold Value	Enter four digits for Month/Day, six digits for Time, or four digits plus decimal point and minus sign for DC thresholds.
PLn	Printer Select (Note 5)	PL1 = ALL Printout PL2 = PART Printout
Pn or PSn	PRESET TEST Select or Save	P1 = Preset Test 1 PS1 = Save Preset Test 1 P2 = Preset Test 2 PS2 = Save Preset Test 2 P3 = Preset Test 3 PS3 = Save Preset Test 3 P4 = Preset Test 4 PS4 = Save Preset Test 4

Table 3.4 - continued

Code Letter	Function Title	Descriptions and Subfunctions "n" (where "n" is identified by a number)
Qn	Data Request	Q1 = Dump measurement for both error types Request (B, V) and DC Monitor. The length, format and content are controlled by the ERROR THRESHOLD (THn), Length (XLn), Format (XFn) selected, and Printout Trigger (XPn). Q2 = Dump current time, elapsed time, and time remaining as applicable to current test. The format is controlled by XFn. Q3 = Dump receiver status. Q4 = Dump measurements for only the error type selected (Dn command). The length, format and content are controlled by the ERROR THRESHOLD (THn), Length (XLn), Format (XFn) selected, and Printout Trigger (XPn). Q5 = Dump Error Burst measurements. The format is controlled by XFn. Q6 = Dump Demultiplexer Status. Q7 = Power-Down and Power-Up Times.
RE	Enable Remote Operation	Changes the unit status to remote. Required for RS-232C operation as unit will not respond to any commands unless it is in the remote state. Does not affect IEEE-488.
RD	Disable Remote Operation	Changes the unit status back to local operation. Does not affect IEEE-488 operation.
Sn	Set Clock to Entered Value	S1 = Set MONTH-DAY to entered value S2 = Set TIME OF DAY to entered value
SR	Serial Poll Acknowledge	Allows the unit to update the serial poll status. (See Serial Poll Bit Assignment.)
SV	Save Threshold	Saves a programmable threshold. Requires up to six digits (0-999999) for threshold information.
THn	ERROR THRESHOLD Select (Note 4)	TH1 = ALL TH2 = 10^{-6} TH3 = PROG TH4 = 10^{-3}

Table 3.4 - continued

Code Letter	Function Title	Descriptions and Subfunctions "n" (where "n" is identified by a number)
Tn	Select TIME Display Mode	T1 = MONTH-DAY Display T2 = TIME OF DAY Display T3 = ELAPSED-TIME Display T4 = SINGLE-TIMED Display T5 = REPEAT-TIMED Display T6 = HI DC THRESHOLD T7 = LO DC THRESHOLD
WY	Identify	Returns unit identification. ETX before the last CR/LF will indicate the last three bytes. EOI will be set for IEEE-488 operation.
XFn	FORMAT Select	XF1 = Select "machine" mode for output formatting (see examples in section E.). XF2 = Select "human" mode for output formatting (same as printer option format)
XLn	LENGTH Select (Note 5)	XL1 = ALL Printout on Remote Interface. XL2 = PART Printout on Remote Interface.
XMn	Log MODE	XM1 = Log on request only (Note 6) XM2 = Auto log in sequence TOTAL & % Error Seconds: TOT ERR, AVG ERR, DC IN 1, DC IN 2, and Burst Data.
XPn	Printout Trigger	XP1 = Trigger on DCV out of threshold XP2 = Trigger on Errors XP3 = Trigger on either DCV out of threshold or Errors.
XTn	TIME Line Select	XT1 = No TIME line with data. XT2 = Output real TIME and date with data.

NOTES:

1. In DS1, only channel 1 may be selected; in DS1C channel 1, 2, or both may be selected; in DS2, any channel or all four may be selected. Channels may not be selected if operating unframed DS1C or DS2.

2. Standard ELAPSED Test: Automatically formats and performs C3 (Clear all flags and accumulators), N0 (zero time), TH1 (ALL Threshold), T3 (selects ELAPSED time display), D1 (display BIT ERROR), M1 (display TOTAL ERROR SECONDS), XM2 (provide log signals on any error types), XT2 (provide real TIME signal with transmitted data), and J2 (start Timer and operate RUN to on).

3. Standard TIMED Test: Must be preceded with N (a Time value) and T4 or T5 instructions. The system then automatically formats and performs C3 (Clear all flags and accumulators), D1 (display BIT ERROR), M1 (display TOTAL ERROR SECONDS), TH1 (ALL Threshold), XM2 (output all ERROR types), XT2 (provide real TIME signal with transmitted data), and J2 (start Timer and operate RUN to on).

4. ERROR THRESHOLD does not affect data acquisition, but how acquired data is displayed. Each ERROR SECOND is categorized as to which thresholds its average BER exceeds. When a threshold is selected, only errors occurring in seconds for which the average BER exceeded that threshold will be considered in computing the measurement values.

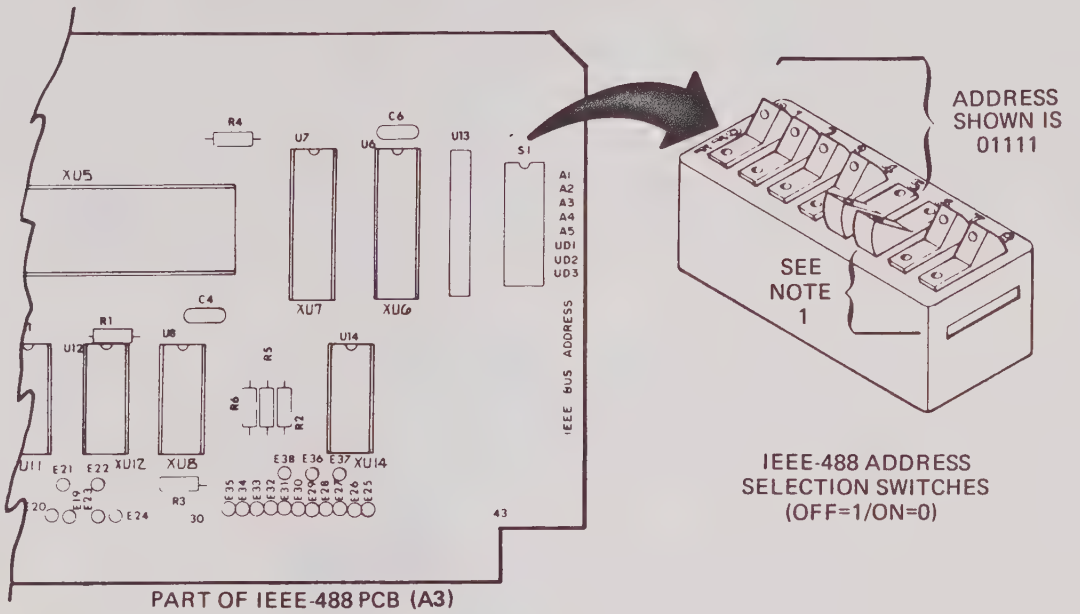
5. If the ALL printout is selected, the selected ERROR THRESHOLD affects the data printed as follows: If the ALL threshold is selected, results for all four thresholds are printed. If a threshold other than ALL is selected, results for the selected threshold and the ALL threshold are printed. If the PART printout is selected, only the results for the selected threshold are printed.

6. The XM1 command (Log on request only) should generally be issued to prevent AUTO LOG results from being confused with the results of a Request for Data.

B. IEEE-488 INTERFACE OPTION

1. Installation

The IEEE-488 Interface option (Part No. 304208) can be installed in the Model 4654A Analyzer during a routine maintenance check if desired. The IEEE-488 Interface Bus printed circuit board must be installed in the correct card cage assembly slot as shown in Figure 3.10. Before inserting the printed circuit board, observe the DIP switch (upper right hand corner) for correct Bus Device Address switch settings. Addressing is straight binary coding as shown in Figure 3.9. The bus address is displayed in the seconds digits of the time display at power-up. A "t0" in these digits indicates the unit is set to "talk only" mode. The Model 4654A Analyzer can be configured as a "talker/listener" or in "talk only" mode for direct logging of measurements on a bus compatible printer. It can not be configured as a system controller. When the switch code is verified, install the printed circuit board securely in the proper slot connector.



NOTES:

1. SWITCH POSITIONS UD3, UD2, UD1 MUST BE SET TO "0, 0, 0" FOR "TALK/LISTEN MODE" OR TO " 1, 0, 0" FOR "TALK ONLY MODE."
2. THESE COLUMNS IDENTIFY THE BUS ADDRESS IN BOTH HEXIDECIMAL AND DECIMAL.

Bus Address (Note 1)		A5	A4	A3	A2	A1	←PCB Reference→	A5	A4	A3	A2	A1	Bus Address (Note 1)	
HEX	DEC	5	4	3	2	1	←Switch Number→	5	4	3	2	1	HEX	DEC
01H	01	0	0	0	0	1		1	0	0	0	0	10H	16
02H	02	0	0	0	1	0		1	0	0	0	1	11H	17
03H	03	0	0	0	1	1		1	0	0	1	0	12H	18
04H	04	0	0	1	0	0		1	0	0	1	1	13H	19
05H	05	0	0	1	0	1		1	0	1	0	0	14H	20
06H	06	0	0	1	1	0		1	0	1	0	1	15H	21
07H	07	0	0	1	1	1		1	0	1	1	0	16H	22
08H	08	0	1	0	0	0		1	0	1	1	1	17H	23
09H	09	0	1	0	0	1		1	1	0	0	0	18H	24
0AH	10	0	1	0	1	0		1	1	0	0	1	19H	25
0BH	11	0	1	0	1	1		1	1	0	1	0	1AH	26
0CH	12	0	1	1	0	0		1	1	0	1	1	1BH	27
0DH	13	0	1	1	0	1		1	1	1	0	0	1CH	28
0EH	14	0	1	1	1	0		1	1	1	0	1	1DH	29
0FH	15	0	1	1	1	1		1	1	1	1	0	1EH	30
(continued in next column)								1	1	1	1	1	1FH	31

Figure 3.9. IEEE-488 Interface Printed Circuit Board (A3), Bus Address Codes

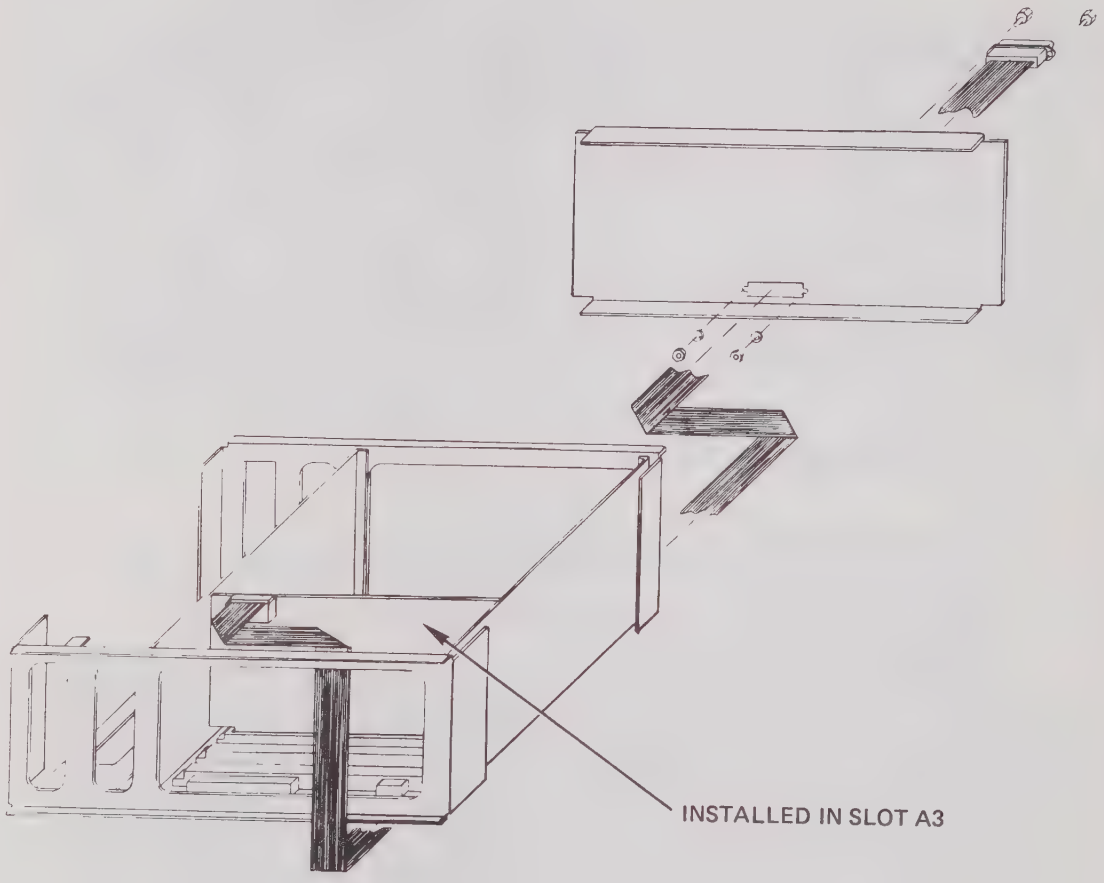


Figure 3.10. Part Number 304208 Assembly, IEEE-488 Interface

Remove the bottom cover from the analyzer. Properly route the interconnecting flat cable (Cable Assembly W11) by passing the smaller connector end from the outside and through the rear panel hole labelled "IEEE-488". The connector should be oriented so the wide part will be closest to the analyzer top cover. Attach the connector to the rear panel with hardware supplied. Run the cable flat, across the bottom of the card cage assembly, then up and through the front of the card cage assembly, connecting it to the A3 printed circuit board.

Replace the analyzer bottom cover. Perform a visual check making sure cables, etc. are correctly positioned. Remount the card cage assembly retainer. Replace the analyzer top cover. The equipment is now ready for bus operation.

2. Special Features of IEEE-488 Interface

a. Parallel Poll Configure

Parallel polling is used on the IEEE-488 Bus to allow up to eight interface compatible equipments to return a one-bit status to the system controller. An active parallel poll bit indicates a unit is in need of service by the system controller. Obviously, each unit is assigned different bit locations to use during parallel poll to avoid conflicts. The Model 4654A Analyzer can only be indirectly configured for bit location during parallel polls. Note in Table 3.4, the letter K is used for parallel poll configuration. After the system controller has addressed the Model 4654A Analyzer to be a listener, the controller issues a K1 or K2 (through K8) command to assign the parallel poll bit location. When the analyzer is powered-up after a shutdown condition, it automatically selects the parallel poll bit that was selected before power-down.

b. Serial Poll Bit Assignment

The Serial Poll is activated by the system controller enabling the Serial Poll Mode State and then addressing an individual device to put its status

bits on the bus. This allows each unit on the bus to respond to the system controller with up to eight unique status bits. The Model 4654A Analyzer uses these bits for Signal Loss, Framing Loss, Secondary Alarm, Measurement Complete, and Command Errors as shown in Figure 3.11. A logic "1" indicates the condition is true. A Command Error is an unrecognized command to the Model 4654A Analyzer. For example, the analyzer will not accept an "L1" which is not an input command. Secondary Alarms are Data Loss, Power Loss, Excess Zeros, All Ones, DC out of threshold, or Alarm input active. Data pending indicates that the Model 4654A has data waiting to be output. Demux is active if the optional Model 4656 DS3-DS2 Demultiplexer has a signal loss, frame loss, or blue signal condition. To receive the current status information, issue two SR commands. If only one SR is issued, the data will be the status prior to the current status. If no SRs are issued, the data will be from two status changes ago.

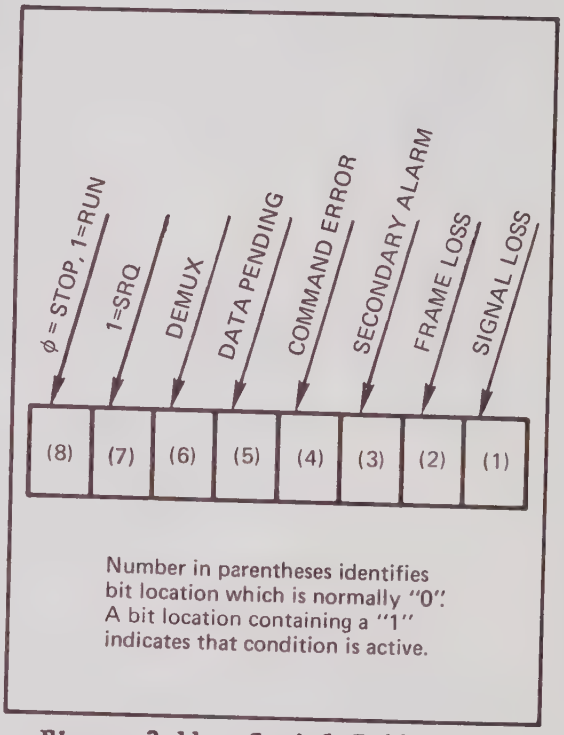


Figure 3.11. Serial Poll Bit Assignment

c. Group Execute Trigger (GET) and Device Trigger

The Group Execute Trigger (GET) and Device Trigger signals are used to let devices on the bus, either individually or in groups, be triggered or to start some action. As applied to the Model 4654A Analyzer, a received GET or Device Trigger signal is equivalent to pressing the front panel RESET switch. Pressing the RESET switch will (1) restart the test if timer is in RUN, or (2)

clear both accumulators and status memory indicators to begin a new measurement when the timer is in STOP mode. The trigger commands have no effect on timer operation and the timer will only start and stop through "J" commands as indicated in Table 3.4. A second reason for not starting the clock with trigger commands is that the clock always runs and the timer waits for the next one-second pulse to begin an ELAPSED or a SINGLE-TIMED/REPEAT-TIMED count. Therefore, the GET or Device Trigger signals can only be used to start an untimed error rate measurement.

d. Device Clear or Selective Device Clear

A Device Clear or Selective Device Clear signal addressed to the Model 4654A Analyzer is equivalent to a power-up restart except the IEEE-488 Interface is not reconfigured.

e. Service Request

The Service Request signal lets the equipment indicate to a system controller that an event has occurred, and requests the controller to take some specific action. The normal procedure after receiving a Service Request is for the system controller to perform a Parallel Poll to determine which equipment or device requires service, and then performs a Serial Poll to determine which event within the equipment or device has occurred that needs service. Serial Poll assignments applicable to the Model 4654A Analyzer are provided in Section b and Figure 3.11. A Service Request signal is initiated whenever any of these conditions change status, except the Command Error and Measurement Complete, which only requests service when switched "True".

f. Talk Only

In dedicated applications where an IEEE-488 Bus compatible printer or logging device is available to record the error measurements, and there are no other devices on the bus, then a system controller is not required. The Model 4654A Analyzer can be conditioned to the "talk-only" mode, and the associated printer to the "listen-only" mode, and error measurements can be directly re-

corded. The analyzer would be operated manually through front panel controls but measurement data would still be output over the Bus for recording. If desired, see Figure 3.9 for instructions to establish the "Talk Only" mode of operation. When the IEEE-488 board is set for talk only mode, the analyzer will display "to" in the seconds digits of the time display at power-up instead of the IEEE bus address.

C. RS-232C INTERFACE OPTION

1. General

The RS-232C Interface for the Model 4654A Analyzer is available as Part Number 304209. This option is a serial interface through which all front panel functions can be controlled, measurements can be stopped and started, data requests can be made, and error logging can be provided. The interface software is written to accept commands that can easily be generated by an operator from an RS-232C compatible data terminal. These commands can also be generated by an automatic data collection system under computer control.

Input commands to the Model 4654A Analyzer consist of a series of letters and numbers corresponding to front panel switches. Receiving these combinations is equivalent to an operator pressing the switch. For example, "T2" selects the TIME OF DAY mode, "D1" selects BIT ERROR for display, etc. But there are also commands having no direct equivalent to front panel switches, such as Request for Real-Time, Error Total Real-Time and Elapsed-Time Request (Q2), etc.

Using the RS-232C Interface Option, the operator can command a measurement from the Model 4654A Analyzer and have the measurement results printed at the terminal, whether the terminal is adjacent to the analyzer or operating miles away through a voice quality data modem. The local Printer, Option 4650, can be operated simultaneously with the RS-232C Interface Option to provide remote and local logging of measured results.

2. Installation

The RS-232C Interface option can be installed in the Model 4654A Analyzer during a routine maintenance check if desired. The RS-232C Interface printed circuit board must be installed in the correct card cage assembly slot as shown in Figure 3.12. Before inserting the printed circuit board, the data rate must be set to equal the data modem and terminal with which the Model 4654A Analyzer operates. The data modem used in this service must also be compatible with the Model 4654A Analyzer and associated terminal. This generally requires only that the Modem use full duplex with RS-232C input/output capabilities.

Setting the data rate requires removing the Error Counter printed circuit board (A5) from the card cage assembly and providing the proper jumper combination. The baud rate/jumper requirement is shown in Figure 3.13. When the baud rate has been set, return the A5 printed circuit board to its orginal location. The baud rate will be displayed in the seconds digits of the time display at power-up (1 = 110, 3 = 300, 6 = 600, 12 = 1200, 24 = 2400, 48 = 4800, 96 = 9600, 19 = 19,200).

Remove the bottom cover of the analyzer. Properly route the interconnecting flat cable (Cable Assembly W12) by passing the smaller connector end from the outside and through the rear panel hole labelled "RS 232C". Orient the connector so the wide part is closest to the analyzer top cover. Attach the connector to the rear panel with hardware supplied. Run the cable flat, across the bottom of the card cage assembly, then up and through the front of the card cage assembly. Connect the cable to the A3 printed circuit board.

Replace the analyzer bottom cover. Perform a visual check that cables, etc. are correctly positioned. Remount the card cage assembly retainer. Replace the analyzer top cover, and the equipment is ready for RS-232C operation.

When operating through a modem, the Model 4654A Analyzer is set up as Data Terminal Equipment (DTE); when operating directly to a terminal, it must

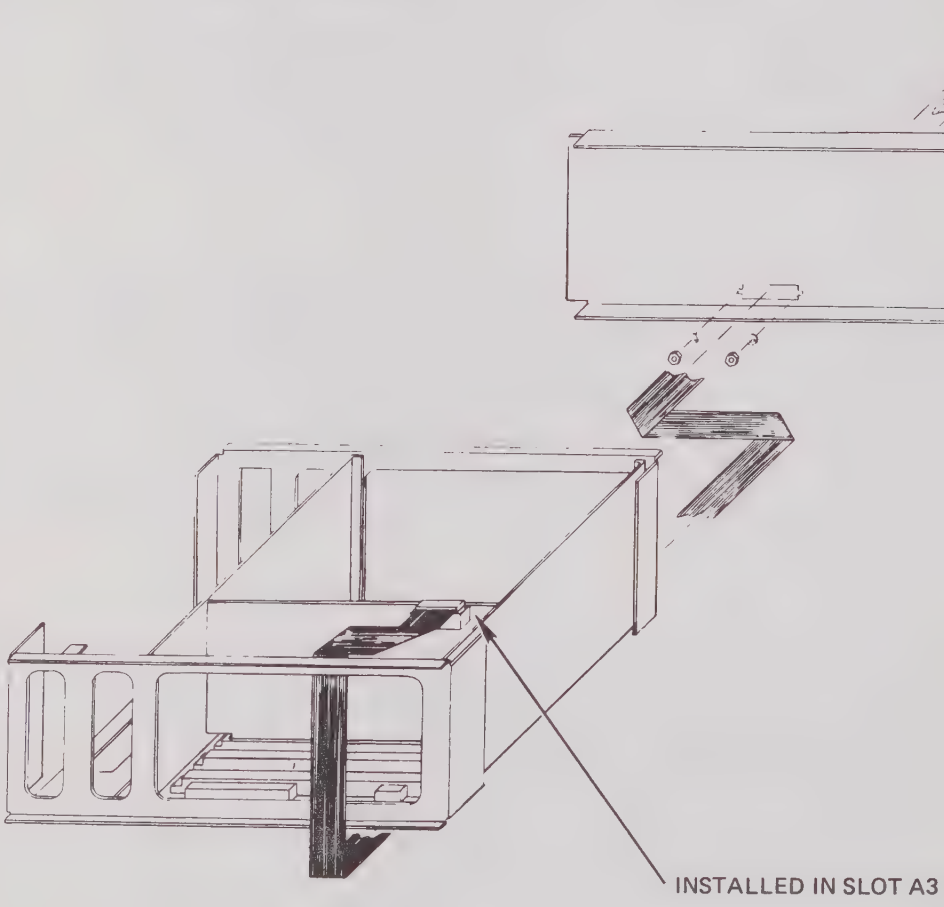


Figure 3.12. Part Number 304209 Assembly, RS-232C Interface

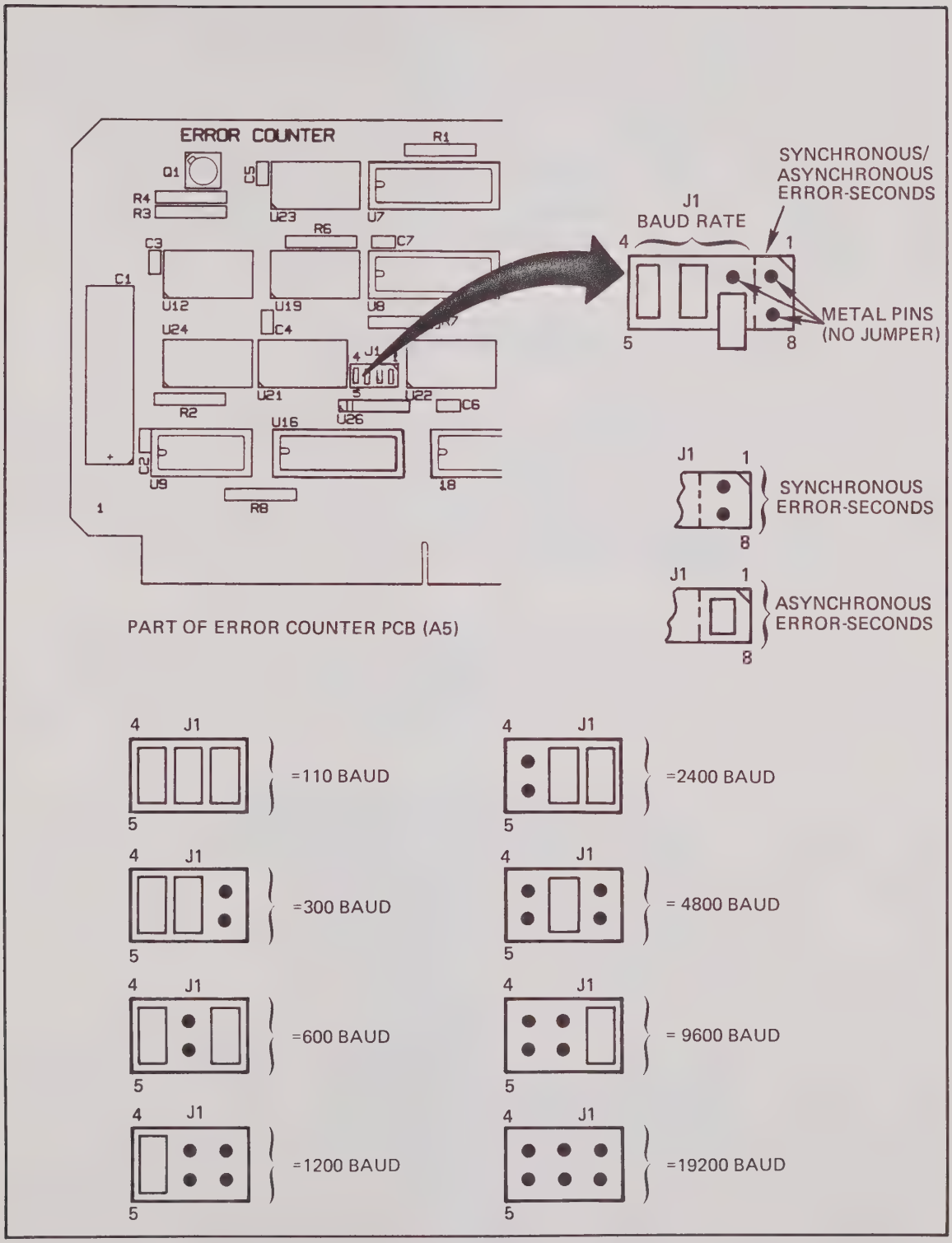


Figure 3.13. Error Counter Printed Circuit Board (A5), Selection of RS-232C Data Rate, and Synchronous/Asynchronous Error-Seconds.

be configured as Data Communications Equipment (DCE), only requiring reversing the Transmitted Data and Received Data signal leads. There may be an installation where, because of the terminal being used, the functions DTR, CTS, RTS, and DSR need to be connected. These connections are shown in Figure 3.14. The Model 4654A Analyzer does not require the use of the modem handshaking lines. If the modem is "auto answer", the analyzer is always ready to send. If the modem is not ready, the analyzer will have no input and the analyzer output will be dumped.

3. Special Features of RS-232C Interface

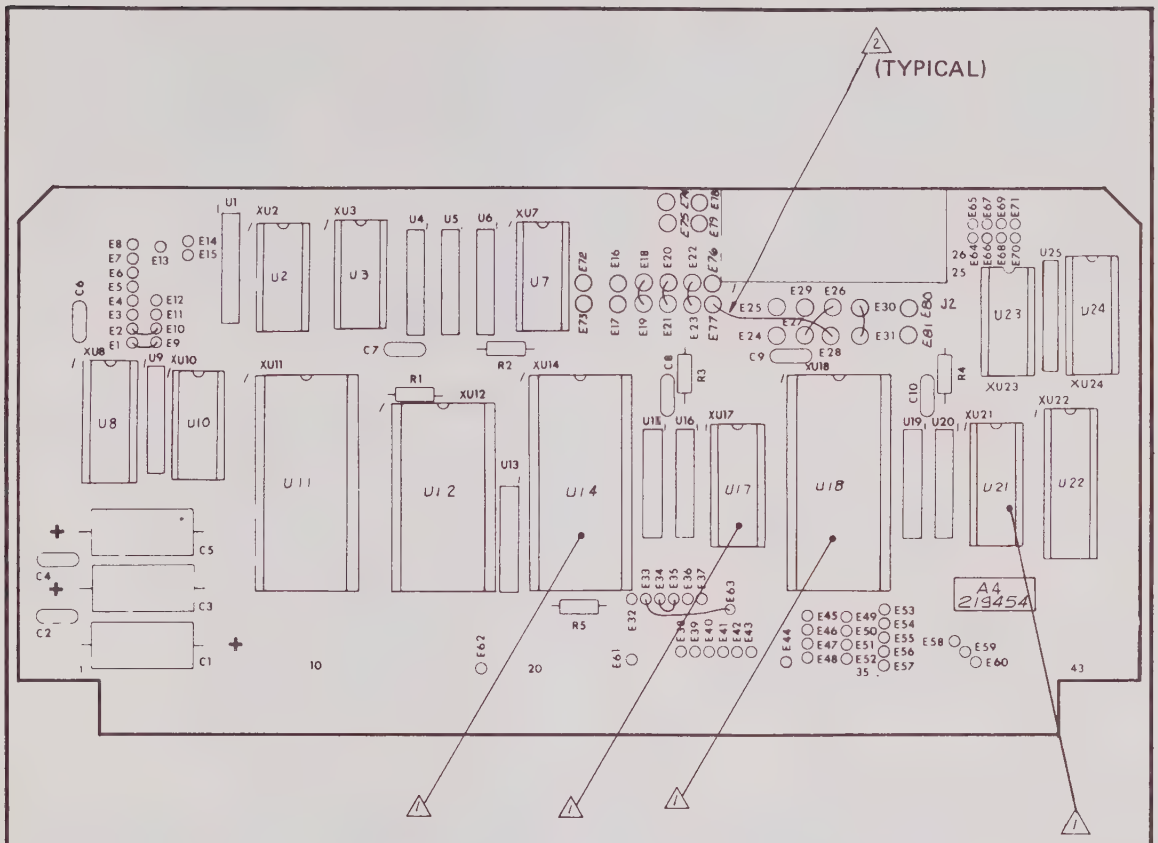
There are two operating modes for the RS-232C interface. After power is applied to the analyzer, it defaults to Full duplex operation. Full duplex implies there can be simultaneous data flow in both directions. Echo-Plex is available through the Echo command. This implies the unit will transmit back (echo) any character that is received.

Before any RS-232C commands can be accepted, a Remote Enable command must be sent to the unit. XON and XOFF (RS-232C commands) are used to control data flow from the unit. A typical serial RS-232C signal format is shown in Figure 3.15.

Table 3.4 lists the input commands. These all apply to RS-232C operation except where noted as applying only to IEEE-488 operation. The examples listed under section D. also apply unless otherwise noted.

D. REMOTE CONTROL EXAMPLES

The following examples show how a Model 4654A Analyzer is operated by remote control. These examples apply to both IEEE-488 or RS-232C operation unless noted that an example applies to a particular interface. Except for the additional overhead of bus protocol (talking, listening, unlistening, etc.), the IEEE-488 Bus commands are simply a series of letter and number sequences to duplicate front panel operation as closely as possible. Additional commands permit data or measurement requests; and the analyzer also provides for



NOTES:

1. U14, U17, U18, U21 not used.
2. Install the following jumpers for all RS-232C boards:
   E1 - E9 E33 - E63
   E2 - E10 E34 - E35
   E3 - E38
3. Install the following jumpers as required for RS-232C option (E26 - E27 connects Signal Ground):
   DCE (For BERTS connection to RS-232C compatible printer)
   E23 to E20
   E21 to E22
   DTE (For BERTS connection to Modem)
   E21 to E20
   E23 to E22
   Other RS-232C option jumpers:
   DTR: E30 to E28 for DCE; E30 to E31 for DTE
   DSR: E29 to E31 for DCE; E29 to E28 for DTE
   RTS: E19 to E16 for DCE; E19 to E18 for DTE
   CTS: E18 to E17 for DCE; E17 to E16 for DTE
   CAR DET: E77 to E78 and E14 to E15 for DCE

Figure 3.14. RS-232C Interface Printed Circuit Board (A3), Jumper Connections for Normal Operation

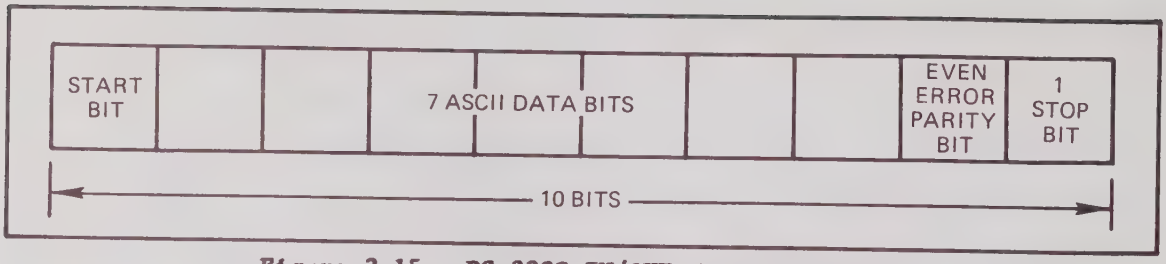


Figure 3.15. RS-232C IN/OUT Message Format

Service Requests, Parallel Polling, Serial Polling, Device Clear, etc., as called for when using the IEEE-488 Bus.

EXAMPLE: START A STANDARD ELAPSED TEST

Operator enters:

J1, H1, DT1, J3

Analyzer responds:

0524 15:10:52 0

START ELAPSED TEST

.

.

.

The J1 command stops the timer, H1 selects the DS1 signal input level, and DT1 selects the PRBS data pattern. These three commands would not be required if the state of the Model 4654A Analyzer is known. The J3 command performs all of the following as if separately entered; C3, N0, TH1, T3, D1, M1, XM2, XT2, J2 (or clear all accumulators, clear all flags, clear the timer, select ALL threshold, select ELAPSED time mode, display BIT errors in TOTAL ERROR-SECONDS mode, print on any error, include time of day, and start test).

EXAMPLE: START A STANDARD TIMED TEST

Operator enters:

J1, N2000000, T4, J4

Analyzer responds:

1225 13:24:08 0

START SINGLE TEST

.

.

.

The J1 command stops the timer if it is running. Presume the input signal and data type are already at the desired settings and that the front panel is disabled or in the desired mode. The N2000000 enters a 200 hour, 00 minute, 00 second test into the TIME display. The T4 command selects the SINGLE-TIMED mode and the J4 command starts a standard TIMED test which is similar to the standard ELAPSED test. The J4 command is also equivalent to C3, TH1, XM2, XT2, D1, M2, J2 (or clear all accumulators, clear all flags, ALL threshold, log errors in the TOTAL ERROR-SECONDS modes, and start the timer).

EXAMPLE: REQUEST TIME

Operator enters:

```
Q2 [carriage return]
```

Analyzer responds:

```
"Human" Mode (XF2)
1005  15:49:47F          60
000:01:00  ELAPSED

"Machine" Mode (XF1)
10,05,15,49,47,1,60,
0,00,01,00
```

In the "Human" mode output, the 1005 is the month and date. The 15:49:47 is the current time. The "F" is a final flag to indicate the end of a test. The 60 is the elapsed test time in seconds. The second line indicates the test elapsed time in hours, minutes, and seconds. If this output was requested during a test, the final flag would not be present, but there would be a third line indicating the time remaining in the test (only for a TIMED test).

The "Machine" mode output presents the same data but in a form more suitable to data processing. The first five numbers are the month, date, and time. The "1" is the final flag; it would be zero if the data was requested during a test. The 60 is the elapsed time in seconds. The next line displays the elapsed time in hours, minutes, and seconds. The single digit before the elapsed time is a flag to indicate the type of time following (0 = Elapsed, 1 = Time Remaining). If the test is an ELAPSED test, the time remaining is not displayed. Note all machine mode outputs are in a fixed format. The same quantity of numbers are output for any given data request output, even if some of the numbers are zero. Each number consists of the same number of digits

(including leading zeros). This fixed output format provides easier programming of a computer to use the data.

EXAMPLE: SET UP AND START A REPEAT TEST

Operator enters:

```
J1, K3, H2, DT2, T5, C1, N100, T5, C2, TH1, D1, M3, XM2, J2
```

Analyzer responds:

```
1225     13:30:10          0
START REPEAT TEST
  .
  .
  .
```

This example uses as many of the commands as is possible to set up a special test configuration. The commands are identified as follows:

```
J1   is Stop the Timer
K3   is Select parallel poll bit 3
H2   is Select DS1C Input
DT2  is OTHER data type
T5   is Select REPEAT-TIMED to set
C1   is Clear Timer
N100 is Enter the time of 1 minute
T5   is set time to 1:00
C2   is Clear All Accumulators
TH1  is ALL Threshold
D1   is Display BIT Error
M3   is Display Total Errors
XM2  is Log (print) All Error Data
J2   is Start Timer
```

EXAMPLE: SET THE CLOCK

Setting the TIME OF DAY and MONTH-DAY are two separate operations.

a. To set TIME OF DAY, which can only be reset when the timer is stopped, the operator selects TIME OF DAY to be set (T2), then enters the new time in 24-hour format. The operator enters the time ahead of the standard to which the analyzer clock is being set. Then as the standard passes through the set time, a SET command is issued. Should the operator enter "T2,N84600,S2" [carriage return] (08 hours, 46 minutes, 00 seconds), the S2 selects the Time Set function. The carriage return should be entered just as the standard passes through "8:46:00" to synchronize the clock.

b. To set the MONTH-DAY, which can only be reset when the timer is stopped, the operator enters the new data as "N1225,S1" [carriage return] for month (12) and day (25). The Model 4654A will immediately update the internal month/day counter when carriage return is pressed. To verify the correct setting, the operator must perform a time request (see EXAMPLE: REQUEST TIME).

E. DATA REQUEST OUTPUT FORMATS
(Qn - Commands - See Table 3.4)

1. Human Mode Outputs (XF2)

EXAMPLE: Q1 Output:

```
0629 16:09:06F     731
          ALL    BER>E-6
ERR B  107552   107544
    V    5271     5244
ES  B      54       46
    V      36       21
%ES B   7.387    6.293
    V   4.925    2.873
%EF B  92.613   93.707
    V  95.075   97.127
BER B  9.53-5   9.53-5
    V  1.14-6   1.14-6
       >3.00-5 BER>E-3
ERR B  107276   104101
    V    4516        0
ES  B      23       14
    V       4        0
%ES B   3.146    1.915
    V   0.547       0.
%EF B  96.854   98.085
    V  99.453     100.
BER B  9.50-5   9.22-5
    V  9.79-7        0
DCV HI     LO    OUTSEC
1+23.12 +10.09      33
2-08.57 -28.52      32
 ERRORS: 1OUT    2OUT
  BIT      350      27
  BPV      826      63
ERROR BURSTS, MSEC
   1-10   11-99   100+
B   730       0       7
```

The Q1 command produces an output like the printout on the Model 4650 printer. The length of the output is controlled by the XLn and THn command. The example is the "ALL" output. If a threshold other than ALL was selected, only data for the ALL threshold and the selected threshold would be output. If the "PART" output (XL2) was selected, only data for the selected threshold and selected error type (BIT or BPV) would be output; with no burst data.

EXAMPLE: Q2 Output:

```
0629 16:10:04F    731
00:12:11  ELAPSED
```

See example in paragraph entitled: EXAMPLE: REQUEST TIME for an example of the Q2 output.

EXAMPLE: Q3 Output:

```
0629 16:10:22F    731
FRAMED DATA
ALARM 1 ON
ALARM 2 OFF
```

This output indicates the current analyzer status.

EXAMPLE: Q4 Output:

```
0629 16:10:38F    731
        ALL    BER>E-6
ERR B 107552   107544
ES  B     54       46
%ES B  7.387    6.293
%EF B 92.613   93.707
BER B 9.53-5   9.53-5
      >3.00-5 BER>E-3
ERR B 107276   104101
ES  B     23       14
%ES B  3.146    1.915
%EF B 96.854   98.085
BER B 9.50-5   9.22-5
```

This output gives data for the selected error type only.

EXAMPLE: Q5 Output:

```
0629 16:11:20F    731
ERROR BURSTS, MSEC
   1-10   11-99  100+
B   730      0     7
```

This output gives burst data and the Front Panel status indicator flags.

EXAMPLE: Q6 Output:

```
0629 16:11:33F    731
-- DEMUX --
FRAME LOSS
CHANNEL 5    DSX
```

This output gives the status of the DS3 to DS2 Demultiplexer.

EXAMPLE: Q7 Output:

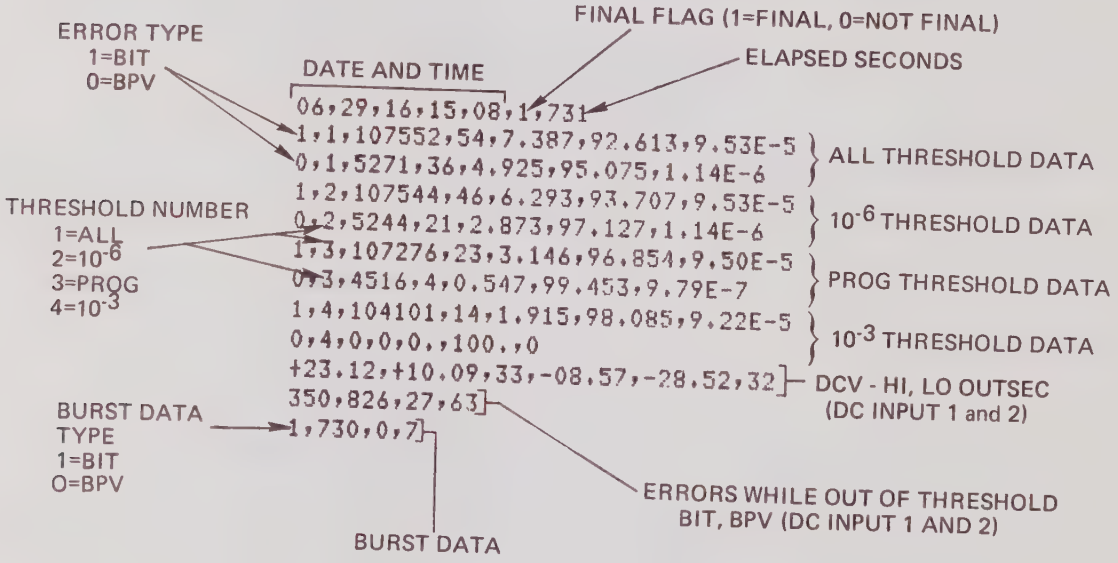
```
0629 16:11:51F    731
0628 21:11:57
POWER DOWN
0629 15:06:58
POWER UP
```

This output indicates the times of the last power-down and power-up.

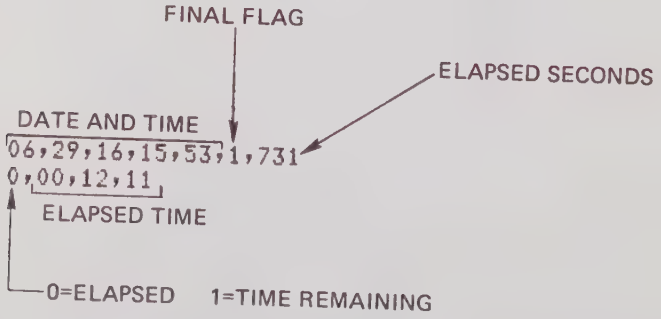
2. Machine Mode Output (XF1)

The following examples contain the same data as the Human Mode outputs in the preceding section (except the current time numbers are different). Compare these examples with the Human Mode Outputs.

EXAMPLE: Q1 Output:

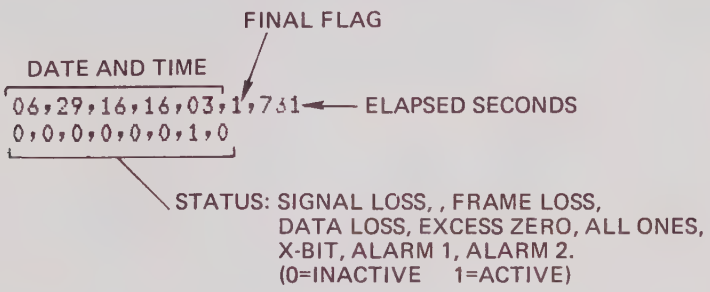


EXAMPLE: Q2 Output:

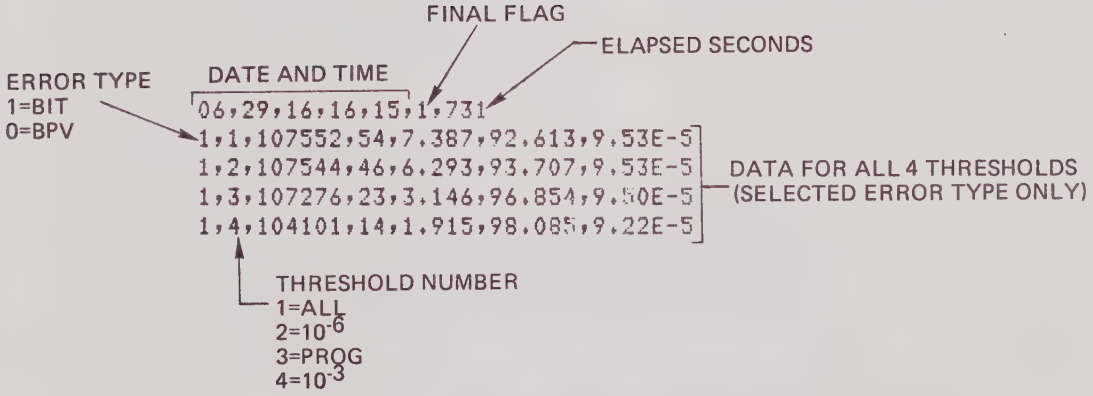


See example in paragraph entitled: EXAMPLE: REQUEST TIME for explanation.

EXAMPLE: Q3 Output: (see note on Human Mode Q3.)

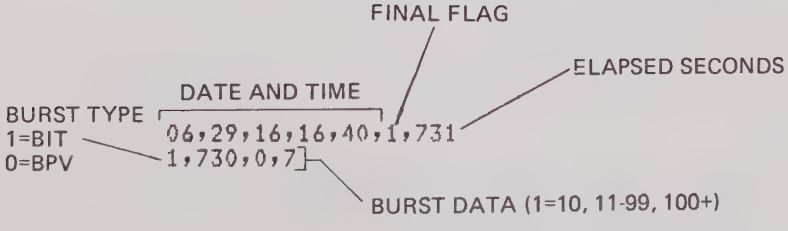


EXAMPLE: Q4 Output:

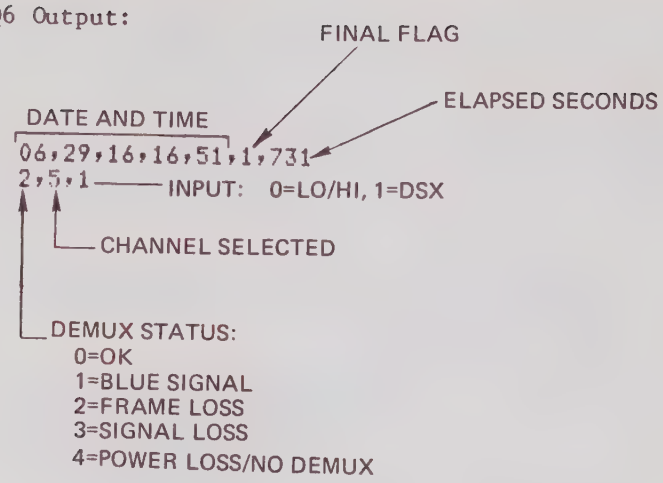


Q4 produces the same output as a Q1 except it is for the selected error type only (Bit or BPV).

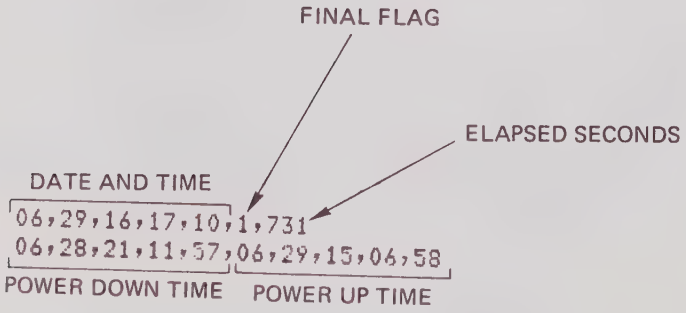
EXAMPLE: Q5 Output:



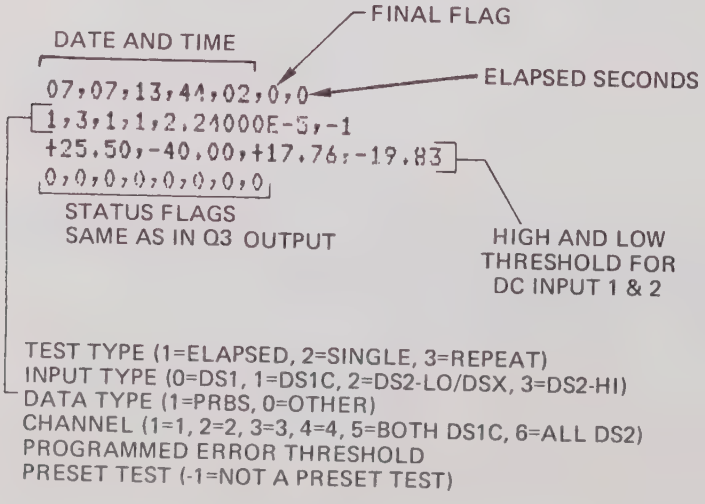
EXAMPLE: Q6 Output:



EXAMPLE: Q7 Output:



EXAMPLE: Machine Mode Start of Test Header:



CONVERSION OF VOLTAGE AND POWER RATIOS TO DECIBELS

The basic chart below indicates the number of decibels (dB) corresponding to the listed ratios of voltage or power over the range of −20 to +20 dB. For voltage or power ratios greater than those included in the chart, the ratio can be broken down into a product of two numbers, the value in dB for each found separately, and the two results added. Example: To convert a power ratio of 2,000:1 to dB, express 2,000 as 2×10^3; the number of dB corresponding to a power ratio of 2 is very nearly 3, and the number of dB for a power ratio of 10^3 is 30. Therefore, the power ratio of 2,000:1 is approximately 30 dB + 3 dB = 33 dB. In the lower righthand corner of the chart dB values for voltage and power ratios of integral powers of 10 are given.

Voltage Ratio	*Power Ratio*	*−dB+*	*Voltage Ratio*	*Power Ratio*	*Voltage Ratio*	*Power Ratio*	*−dB+*	*Voltage Ratio*	*Power Ratio*	*Voltage Ratio*	*Power Ratio*	*−dB+*	*Voltage Ratio*	*Power Ratio*
1.000	**1.000**	**0**	**1.000**	**1.000**	**.447**	**.200**	**7.0**	**2.239**	**5.012**	**.200**	**.0398**	**14.0**	**5.012**	**25.12**
.989	.977	.1	1.012	1.023	.442	.195	7.1	2.265	5.129	.197	.0389	14.1	5.070	25.70
.977	.955	.2	1.023	1.047	.437	.191	7.2	2.291	5.248	.195	.0380	14.2	5.129	26.30
.966	.933	.3	1.035	1.072	.432	.186	7.3	2.317	5.370	.193	.0372	14.3	5.188	26.92
.955	.912	.4	1.047	1.096	.427	.182	7.4	2.344	5.495	.191	.0363	14.4	5.248	27.54
.944	.891	.5	1.059	1.122	.422	.178	7.5	2.371	5.623	.188	.0355	14.5	5.309	28.18
.933	.871	.6	1.072	1.148	.417	.174	7.6	2.399	5.754	.186	.0347	14.6	5.370	28.84
.923	.851	.7	1.084	1.175	.412	.170	7.7	2.427	5.888	.184	.0339	14.7	5.433	29.51
.912	.832	.8	1.096	1.202	.407	.166	7.8	2.455	6.026	.182	.0331	14.8	5.495	30.20
.902	.813	.9	1.109	1.230	.403	.162	7.9	2.483	6.166	.180	.0324	14.9	5.559	30.90
.891	**.794**	**1.0**	**1.122**	**1.259**	**.398**	**.159**	**8.0**	**2.512**	**6.310**	**.178**	**.0316**	**15.0**	**5.623**	**31.62**
.881	.776	1.1	1.135	1.288	.394	.155	8.1	2.541	6.457	.176	.0309	15.1	5.689	32.36
.871	.759	1.2	1.148	1.318	.389	.151	8.2	2.570	6.607	.174	.0302	15.2	5.754	33.11
.861	.741	1.3	1.161	1.349	.385	.148	8.3	2.600	6.761	.172	.0295	15.3	5,821	33.88
.851	.724	1.4	1.175	1.380	.380	.145	8.4	2.630	6.918	.170	.0288	15.4	5.888	34.67
.841	.708	1.5	1.189	1.413	.376	.141	8.5	2.661	7.079	.168	.0282	15.5	5.957	35.48
.832	.692	1.6	1.202	1.445	.372	.138	8.6	2.692	7.244	.166	.0275	15.6	6.026	36.31
.822	.676	1.7	1.216	1.479	.367	.135	8.7	2.723	7.413	.164	.0269	15.7	6.095	37.15
.813	.661	1.8	1.230	1.514	.363	.132	8.8	2.754	7.586	.162	.0263	15.8	6.166	38.02
.804	.646	1.9	1.245	1.549	.359	.129	8.9	2.786	7.762	.160	.0257	15.9	6.237	38.90
.794	**.631**	**2.0**	**1.259**	**1.585**	**.355**	**.126**	**9.0**	**2.818**	**7.943**	**.159**	**.0251**	**16.0**	**6.310**	**39.81**
.785	.617	2.1	1.274	1.622	.351	.123	9.1	2.851	8.128	.157	.0246	16.1	6.383	40.74
.776	.603	2.2	1.288	1.660	.347	.120	9.2	2.884	8.318	.155	.0240	16.2	6.457	41.69
.767	.589	2.3	1.303	1.698	.343	.118	9.3	2.917	8.511	.153	.0234	16.3	6.531	42.66
.759	.575	2.4	1.318	1.738	.339	.115	9.4	2.951	8.710	.151	.0229	16.4	6.607	43.65
.750	.562	2.5	1.334	1.778	.335	.112	9.5	2.985	8.913	.150	.0224	16.5	6.683	44.67
.741	.550	2.6	1.349	1.820	.331	.110	9.6	3.020	9.120	.148	.0219	16.6	6.761	45.71
.733	.537	2.7	1.365	1.862	.327	.107	9.7	3.055	9.333	.146	.0214	16.7	6.839	46.77
.724	.525	2.8	1.380	1.905	.324	.105	9.8	3.090	9.550	.145	.0209	16.8	6.918	47.86
.716	.513	2.9	1.396	1.950	.320	.102	9.9	3.126	9.772	.143	.0204	16.9	6.998	48.98
.708	**.501**	**3.0**	**1.413**	**1.995**	**.316**	**.100**	**10.0**	**3.162**	**10.000**	**.141**	**.0200**	**17.0**	**7.079**	**50.12**
.700	.490	3.1	1.429	2.042	.313	.0977	10.1	3.199	10.23	.140	.0195	17.1	7.161	51.29
.692	.479	3.2	1.445	2.089	.309	.0955	10.2	3.236	10.47	.138	.0191	17.2	7.244	52.48
.684	.468	3.3	1.462	2.138	.306	.0933	10.3	3.273	10.72	.137	.0186	17.3	7.328	53.70
.676	.457	3.4	1.479	2.188	.302	.0912	10.4	3.311	10.96	.135	.0182	17.4	7.413	54.95
.668	.447	3.5	1.496	2.239	.299	.0891	10.5	3.350	11.22	.133	.0178	17.5	7.499	56.23
.661	.437	3.6	1.514	2.291	.295	.0871	10.6	3.388	11.48	.132	.0174	17.6	7.586	57.54
.653	.427	3.7	1.531	2.344	.292	.0851	10.7	3.428	11.75	.130	.0170	17.7	7.674	58.88
.646	.417	3.8	1.549	2.399	.288	.0832	10.8	3.467	12.02	.129	.0166	17.8	7.762	60.26
.638	.407	3.9	1.567	2.455	.285	.0813	10.9	3.508	12.30	.127	.0162	17.9	7.852	61.66
.631	**.398**	**4.0**	**1.585**	**2.512**	**.282**	**.0794**	**11.0**	**3.548**	**12.59**	**.126**	**.0159**	**18.0**	**7.943**	**63.10**
.624	.389	4.1	1.603	2.570	.279	.0776	11.1	3.589	12.88	.125	.0155	18.1	8.035	64.57
.617	.380	4.2	1.622	2.630	.275	.0759	11.2	3.631	13.18	.123	.0151	18.2	8.128	66.07
.610	.372	4.3	1.641	2.692	.272	.0741	11.3	3.673	13.49	.122	.0148	18.3	8.222	67.61
.603	.363	4.4	1.660	2.754	.269	.0724	11.4	3.715	13.80	.120	.0145	18.4	8.318	69.18
.596	.355	4.5	1.679	2.818	.266	.0708	11.5	3.758	14.13	.119	.0141	18.5	8.414	70.79
.589	.347	4.6	1.698	2.884	.263	.0692	11.6	3.802	14.45	.118	.0138	18.6	8.511	72.44
.582	.339	4.7	1.718	2.951	.260	.0676	11.7	3.846	14.79	.116	.0135	18.7	8.610	74.13
.575	.331	4.8	1.738	3.020	.257	.0661	11.8	3.890	15.14	.115	.0132	18.8	8.710	75.86
.569	.324	4.9	1.758	3.090	.254	.0646	11.9	3.936	15.49	.114	.0129	18.9	8.811	77.62
.562	**.316**	**5.0**	**1.778**	**3.162**	**.251**	**.0631**	**12.0**	**3.981**	**15.85**	**.112**	**.0126**	**19.0**	**8.913**	**79.43**
.556	.309	5.1	1.799	3.236	.248	.0617	12.1	4.027	16.22	.111	.0123	19.1	9.016	81.28
.550	.302	5.2	1.820	3.311	.246	.0603	12.2	4.074	16.60	.110	.0120	19.2	9.120	83.18
.543	.295	5.3	1.841	3.388	.243	.0589	12.3	4.121	16.98	.108	.0118	19.3	9.226	85.11
.537	.288	5.4	1.862	3.467	.240	.0575	12.4	4.169	17.38	.107	.0115	19.4	9.333	87.10
.531	.282	5.5	1.884	3.548	.237	.0562	12.5	4.217	17.78	.106	.0112	19.5	9.441	89.13
.525	.275	5.6	1.905	3.631	.234	.0550	12.6	4.266	18.20	.105	.0110	19.6	9.550	91.20
.519	.269	5.7	1.928	3.715	.232	.0537	12.7	4.315	18.62	.104	.0107	19.7	9.661	93.33
.513	.263	5.8	1.950	3.802	.229	.0525	12.8	4.365	19.05	.102	.0105	19.8	9.772	95.50
.507	.257	5.9	1.972	3.890	.227	.0513	12.9	4.416	19.50	.101	.0102	19.9	9.886	97.72
.501	**.251**	**6.0**	**1.995**	**3.981**	**.224**	**.0501**	**13.0**	**4.467**	**19.95**	**.100**	**.0100**	**20.0**	**10.000**	**100.00**
.496	.246	6.1	2.018	4.074	.221	.0490	13.1	4.519	20.42		10^{-3}	30		10^3
.490	.240	6.2	2.042	4.169	.219	.0479	13.2	4.571	20.89	10^{-2}	10^{-4}	40	10^2	10^4
.484	.234	6.3	2.065	4.266	.216	.0468	13.3	4.624	21.38					
.479	.229	6.4	2.089	4.365	.214	.0457	13.4	4.677	21.88		10^{-5}	50		10^5
.473	.224	6.5	2.113	4.467	.211	.0447	13.5	4.732	22.39	10^{-3}	10^{-6}	60	10^3	10^6
.468	.219	6.6	2.138	4.571	.209	.0437	13.6	4.786	22.91		10^{-7}	70		10^7
.462	.214	6.7	2.163	4.677	.207	.0427	13.7	4.842	23.44	10^{-4}	10^{-8}	80	10^4	10^8
.457	.209	6.8	2.188	4.786	.204	.0417	13.8	4.898	23.99		10^{-9}	90		10^9
.452	.204	6.9	2.213	4.898	.202	.0407	13.9	4.955	24.55	10^{-5}	10^{-10}	100	10^5	10^{10}
											10^{-11}	110		10^{11}
										10^{-6}	10^{-12}	120	10^6	10^{12}

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